directional microphone

without parabolic reflector

Directional microphones such as used by, say, outdoor-recording specialists and bird-watchers, are invariably provided with a conspicuous parabolic reflector. This captures an almost parallel beam of sound waves and so reduces the angle of incidence of the microphone. The same action may be obtained in a completely different manner as described in this article.

Design by G. Baars

INTRODUCTION

A directional microphone may be constructed in several ways. The most frequently encountered is that in which the transducer is provided with a mechanical aid that functions as a kind of acoustic lens. This greatly amplifies the narrow beam of sounds in line with the axis of the microphone and usually takes the shape of a parabolic reflector.

The angle of incidence of the sounds may also be narrowed in a different way. In this, the sounds in line with the axis of the microphone are not amplified, but those at an angle to this line are attenuated in proportion to the size of the angle to give the same effect. In this case, of course, the in-line sounds need to be magnified by electronic means,. that is, in an amplifier.

DESIGN CONSIDERATIONS

In the present circuit, yet another approach is used, which depends on the phase of the incident sounds. Speech signals of identical frequency arrive at the microphone with different phases, depending on the location of the source of the sounds. It is therefore possible to select from the mass of sounds arriving at the microphone just one or a specific range that have the same frequency but differ in phase. This cannot be done with a single microphone, however, but with two microphones the results are highly satisfactory. The two microphones are not mounted side by side, as would be expected, but one behind the other, at a specific distance, along their respective axes as in **Figure 1**.

If the two microphones are separated by a half-wavelength of the wanted sound, the sounds will arrive at them with opposite phase. This is because the microphone at the left receives the falling edge of the signal and the microphone at the right the rising edge. If these signals are amplified and then subtracted from one another in a differential amplifier, the output of that amplifier will be a strong signal at the wanted frequency.

Signals arriving at the microphones in phase (that is, at an angle to the line joining the axes of the microphones) oppose one another in the differential amplifier and will thus be strongly attenuated.

A bonus of this approach is that interfering low-frequency signals, such as traffic noise or wind noise, invariably arrive at the microphones in phase and will thus be greatly attenuated.

It is obvious that the distance between the microphones is of crucial importance for effective directional operation. After many experiments, a distance of 20 cm (8 in) was found to be the best compromise. This distance corresponds to the half-wavelength of a signal at 850 Hz, which is at a convenient point in the speech band of 200–3000 Hz. The electronic circuits associated with the microphone are therefore designed for selective amplification of this band.

CIRCUIT DESCRIPTION

The diagram in **Figure 2** makes it clear that the circuit is not very complicated. It consists of input amplifiers IC_{1b} and IC_{1c}, differential amplifier IC_{1d}, and a simple headphone amplifier consisting of IC_{1a} and T_1 and T_2.

The outputs of microphones MIC_1 and MIC_2 are applied to IC_{1b} and IC_{1c} respectively. The microphones are electret types, whose supply voltage is derived from the supply lines via R_1 and R_2 respectively. Since the sensitivity of these microphones, especially inexpensive types, has a wide tolerance, preset P_1 is provided to match that of MIC_1 to MIC_2.

The *RC* networks associated with the input amplifiers limit the bandwidth of the input as stated earlier to 200–3000 Hz. Networks R_6-C_6, R_7-C_7, R_1-P_1-C_1, and R_2-C_2, form low-pass sections, whereas R_3-C_3, R_4-C_4, and R_5-C_5, are high-pass sections.

The amplified signals are subtracted from one another by differential amplifier IC_{1d}. Here also, networks R_8-R_9-C_8 and R_{11}-C_9 serve to keep the bandwidth within the stated limits.

The level of the differential signal at the output of IC_{1d} may be adjusted with P_2. The signal at the wiper of this potentiometer is applied to the input of the simple headphone amplifier, which consists of IC_{1a} and transistors T_1 and T_2. Again, networks R_{13}-C_{11} and R_{12}-C_{10} serve to keep the bandwidth within the earlier stated limits.

Resistor R_{15} ensures that output current of the headphone amplifier is kept within certain limits to avoid overloading of the battery at low output impedances. Bear in mind that the impedance of many small headphones, even with both ear-pieces in series, is of the order of only 16 ohms.

The operational amplifier used is a low-noise type which has the added advantage of needing only a low supply voltage. Also, it draws a current of not more than 7.5 mA. This enables the microphone to be powered by a single 9 V battery (dry or rechargeable).

Potential divider R_{16}-R_{17} arranges the supply lines to the input amplifiers at half the battery voltage. The supply lines are well decoupled by capacitors C_{13}–C_{16} to make certain that there is no feedback of spurious signals along these lines. This is particularly important when the battery reaches the end of its life (or charge, as the case may be), and then has a high internal impedance. The supply lines to the microphones are additionally decoupled by R_{18}-C_{17}.

FINALLY ...

The electronic circuits are best built on the printed-circuit board shown in **Figure 3**, which is available ready-made through our Readers Services. Constructing the board is a very simple affair, indeed.

The completed board and the 9-V battery can be housed conveniently in a small case. Connect the microphones to the assembly via screened microphone cable.

The final shape of the directional microphone assembly depends largely on the constructor's preferences and ingenuity. It is important, however,

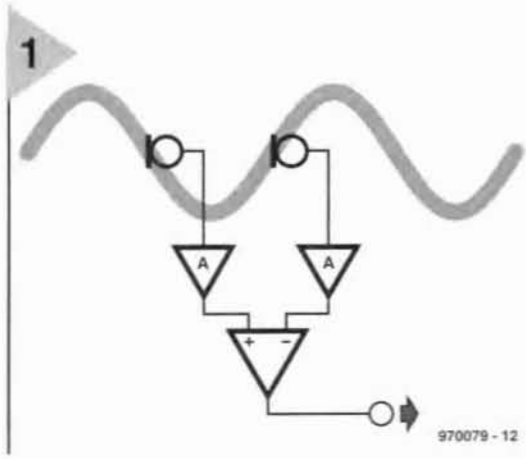
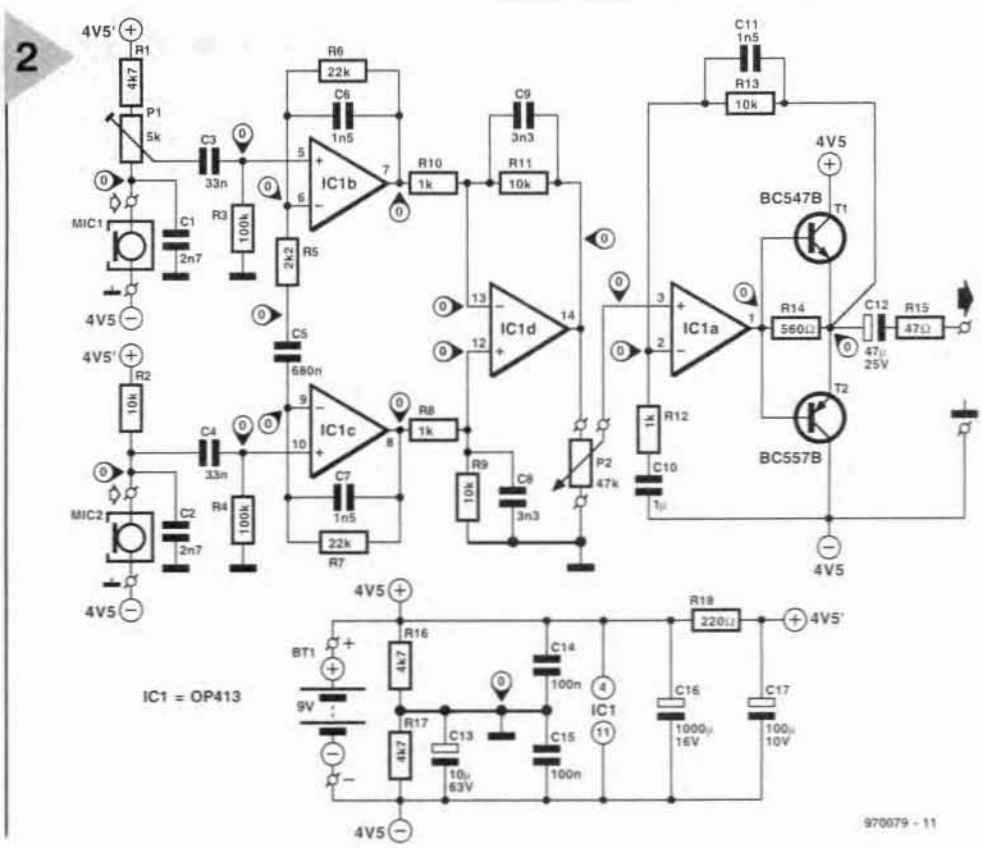


Figure 1. Basic setup of the directional microphone. A signal is passed to the output only if the sounds picked up by one microphone are out of phase with those picked up by the other microphone.

Figure 2. The circuit diagram of the requisite electronics for the directional microphone.



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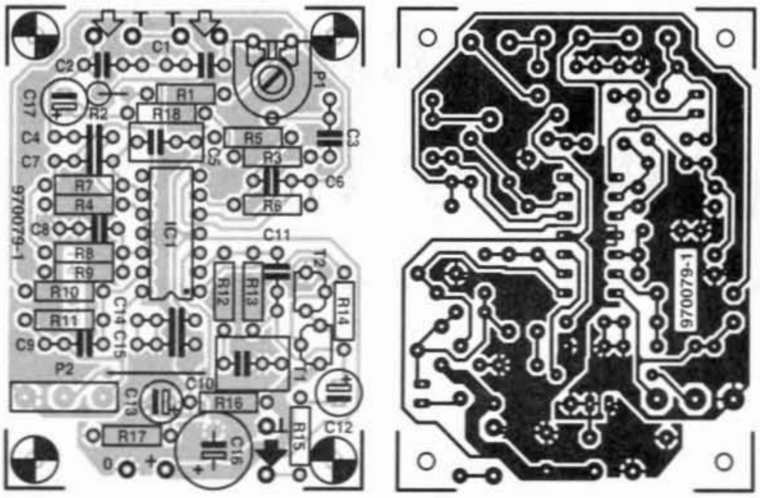
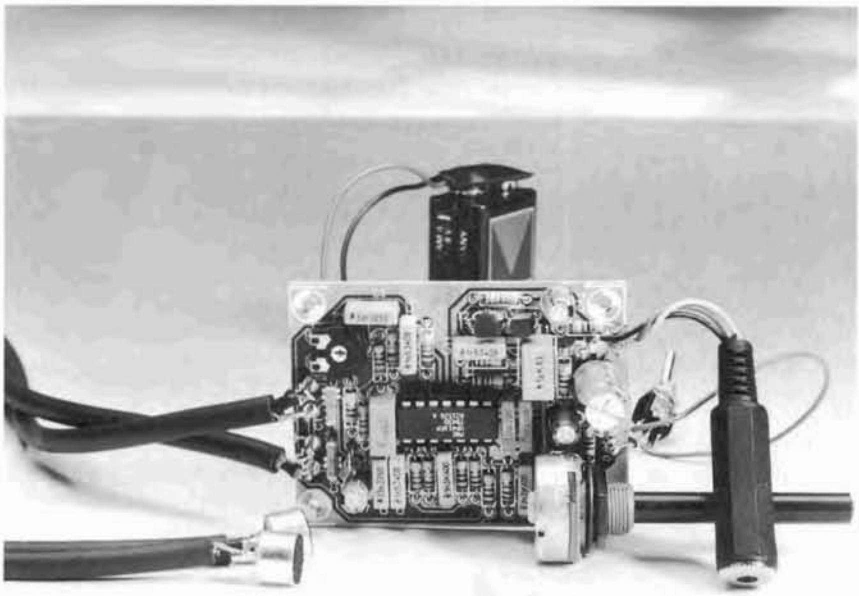


Figure 3. The printed-circuit board for the directional microphone is available ready-made.



Parts list

Resistors:

R_1, R_{16}, R_{17} = 4.7 kΩ
R_2, R_9, R_{11}, R_{13} = 10 kΩ
R_3, R_4 = 100 kΩ
R_5 = 2.2 kΩ
R_6, R_7 = 22 kΩ
R_8, R_{10}, R_{12} = 1 kΩ
R_{14} = 560 Ω
R_{15} = 47 Ω
R_{18} = 220 Ω
P_1 = 4.7 kΩ (5.0 kΩ) preset
P_2 = 47 kΩ log potentiometer

Capacitors:

C_1, C_2 = 0.0027 μF
C_3, C_4 = 0.033 μF
C_5 = 0.68 μF
C_6, C_7, C_{11} = 0.0015 μF
C_8, C_9 = 0.0033 μF
C_{10} = 1 μF, metallized polyester (MKT), pitch 5 mm or 7.5 mm
C_{12} = 47 μF, 25 V, radial
C_{13} = 10 μF, 63 V, radial
C_{14}, C_{15} = 0.1 μF
C_{16} = 1000 μF, 16 V, radial
C_{17} = 100 μF, 10 V, radial

Semiconductors:

T_1 = BC547B
T_2 = BC557B

Integrated circuit:

IC_1 = OP413FP (Analog Devices)

Miscellaneous:

MIC_1, MIC_2 = electret microphone
BT_1 = 9 V battery, dry or rechargeable, with connecting clips
PCB Order no 970079-1 (see Readers Services elsewhere in this issue)

that the microphones are fixed 20 cm apart on some sort of carrier.

SOME TECHNICAL DATA

The characteristic of the pass-band of the directional microphone assembly is shown in **Figure 4**. As mentioned in the text, the –3 dB cut-off points are at 200 Hz and (just below) 3000 Hz The centre frequency may be assumed at about 850 Hz.

The overall voltage amplification of the circuit is about ×1800 (65 dB).

The harmonic distortion is <0.1% measured at a frequency of 750 Hz with a load impedance of 600 Ω.

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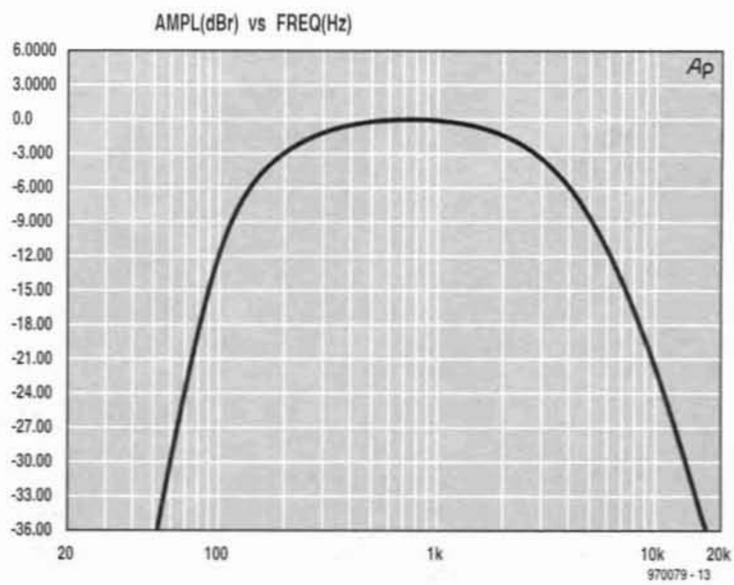

Figure 4. The pass-band of the directional microphone covers the normal speech band.