

design ideas

Edited by Bill Travis

Clip extracts signal from phone line

Maxwell Strange, Fulton, MD

USING A capacitive-coupled clip, you can pick up the signal from a twisted-pair or -wire telephone line or from other unshielded analog lines without piercing the insulation. No line test can detect the clip's presence, and it leaves no evidence of having been attached. It

needs no ground return. You can fasten the small, insulated pickup plates to the opposing jaws of an alligator clip for quick and easy attachment. Balanced lines from the plates connect to the inputs of a high-impedance differential amplifier (Figure 1). For this scheme to have satisfactory signal-to-noise and frequency-response parameters, the clip, connecting cable, and amplifier must be attached parallel to the signal wire and must be as long

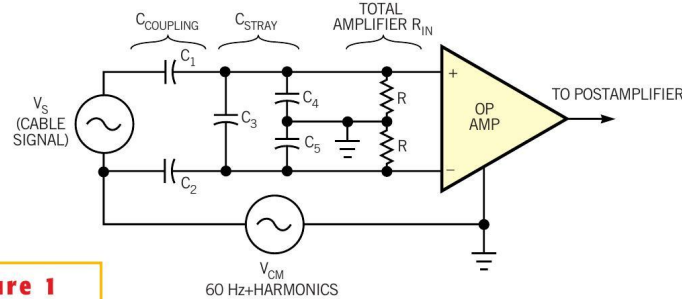


Figure 1

In this equivalent circuit, you should maximize the coupling capacitances, C_1 and C_2 , and minimize the stray capacitances, C_3 , C_4 , and C_5 .

interference, typically comprising 60-Hz signals and their harmonics from power-line fields. The cable should have good electrical symmetry and low total capacitance between conductors and to the shield. Thus, the amplifier must be near the clip. The amplifier should have high input resistance, low current noise, and adequate common-mode rejection.

put sees and reduces the circuit's noise by the square root of the signal attenuation. The noise reduction accrues from reducing the needed input resistance. Therefore, you generally don't need the complication of an insulated "bootstrapped" shield. You can follow the amplifier with a nearby or remotely located post-amplifier for more gain and bandpass filtering to optimize the signal-to-noise per-

formance. A telephone signal has a bandwidth of approximately 300 Hz to 3 or 4 kHz. A sharp highpass cutoff at 300 Hz effectively rejects power-line noise pickup. A simple, two-pole, Sallen-Key Butterworth filter works well. You can trim it to provide some high-frequency peaking to obtain the most intelligible signal.

A multiple-pad pickup scheme improves noise rejection (Figure 2). The circuit's arrangement is such that even-numbered pads on one side and odd-numbered pads on the other side pick up equal noise that produces opposite-phase outputs from op amps A and B. Op amp C then sums the signals and rejects the noise. The desired difference signal, however, appears in-phase at the outputs of A and B, so both op amps con-

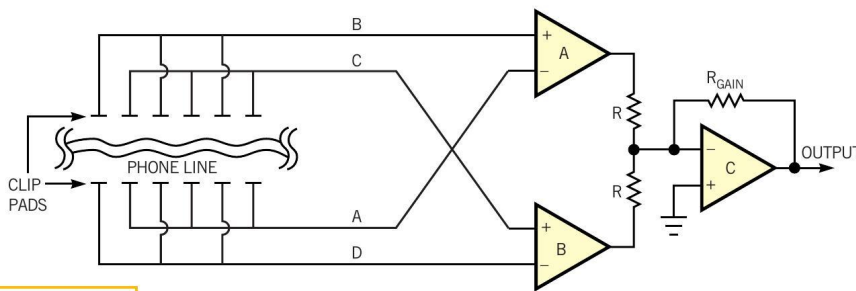


Figure 2

A multiple-pad approach produces cancellation of equal noise that the opposed pad pairs pick up.

as is conveniently possible—an inch or more—and preferably slightly curved to maximize the coupling capacitance. (For a twisted-conductor line, the plates should not be longer than the twist "wavelength" to avoid signal cancellation.) You should orient the clip for the cleanest signal output.

The clip, its connecting cable, and the amplifier must be shielded to minimize

The clip's coupling capacitance and stray capacitance and the amplifier's input resistance determine the low-frequency cutoff of the detected signal. Stray capacitances in the clip and in its connecting cable to the shield are generally much larger than the coupling capacitance. Thus, voltage-divider action reduces the signal, but the stray component adds to the capacitance the amplifier's in-

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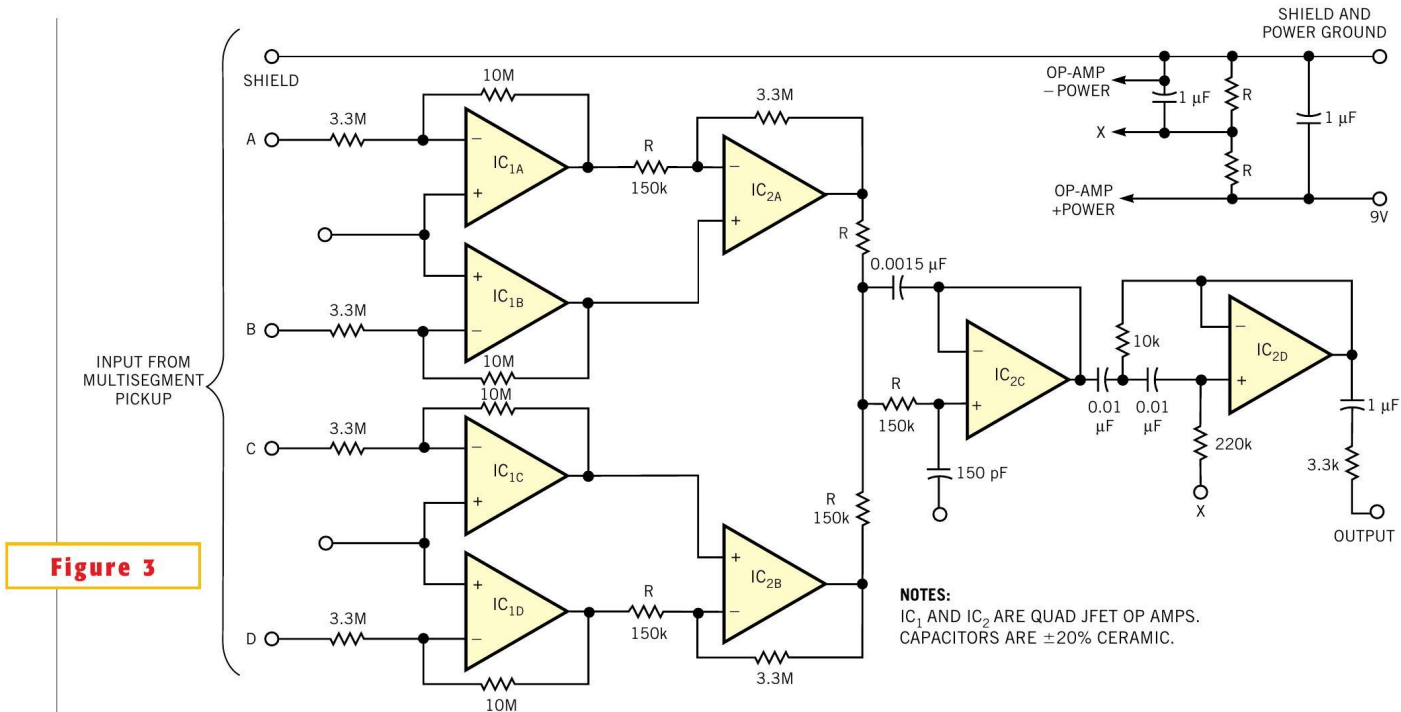


Figure 3

This amplifier, using the multiple-pad approach effectively reduces power-line-related noise pickup.

tribute equally to the output. You can make a segmented pickup from pieces of two-sided pc board with the solid-copper side serving as a shield. You can solder the shield side of the pieces to a suitable alligator clip. Alternatively, for longer term use, you can simply tape them onto the cable. You can use any even number of pads, the more you use, the better, but eight on each side are sufficient.

The amplifier of **Figure 3** uses two quad J-FET or BiFET op amps. Thanks to

stray capacitance on the input lines of the test model, a relatively low input resistance of 3.3 MΩ is sufficient. Input noise is mostly the Johnson noise of the 10-MΩ feedback resistors. Power-line noise pickup is usually the bigger problem. The output stages incorporate some highpass filtering to reject noise below 300 Hz. The output level depends on many factors but is approximately 50 mV. A postamplifier (not shown) can provide more equalization, filtering, and gain if necessary, as

well as manual or automatic level control. Tests of models of both design approaches use readily available components and show perfectly clear telephone speech through a small speaker in the postamplifier box. The multiple-pad pickup system produces noticeably lower noise, and clip orientation is less critical. □

Circuit produces variable frequency, duty cycle

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THIS DESIGN IDEA shows a simple, low-cost circuit that produces a highly accurate variable-frequency and variable-duty-cycle output (**Figure 1**). Further, the duty cycle and frequency are independent of each other (excluding 0 and 100% duty cycle). The method derives its accuracy and stability from the fact that the output is based on a crystal oscillator and divisions of the oscillator's frequency. The design uses only six de-

vices. IC₁, a 74HC393 binary ripple counter, has as its input is the oscillator's output frequency. The outputs are the oscillator frequency divided by two, four, eight, 16, 32, 64, 128, and 256. IC_{5B} is cascaded with IC₁ to divide the oscillator frequency further by 512, 1024, 2048, and 4096. In this circuit, the divide-by-128 is the largest division it uses. You could, with a simple wiring change, substitute an unused divider to obtain a different

output-frequency range. The eight inputs of IC₂, a 74HC151 eight-line-to-one-line multiplexer, connect to the oscillator's frequency divided by one, two, four, eight, 16, 32, 64, and 128. Note that the oscillator's output connects directly to an input of IC₂. This connection allows selecting the oscillator's frequency divided by one. IC₂ connects one of the eight frequencies to the input of IC₃.

IC₃, a 74HC4017 decade counter, di-