Build An Audio Phase Detector

Charles Kitchin*

For the owner of a modest stereo system utilizing one speaker per channel, phasing the speakers is a relatively easy task. By correctly connecting the speakers by their polarity dots or by switching the leads to one speaker and listening for the most solid bass response and best stereo centering, proper phasing is accomplished.

However, if more than one amplifier is used such as in biamp and triamp systems, speaker phasing can become a horror show. Unless the amplifiers are identical (i.e., the same phase shift in each), wiring up the speakers by polarity will not work. The problem is compounded by the electronic crossover which may, or may not, have the bass, midrange, and/or treble outputs in phase with one another. Also, microphones and audio lines are difficult to phase correctly.

Device Description

A simple and inexpensive solution to this problem is to send a coded signal through the system. It is then picked up on a portable receiver which can listen to each speaker individually and indicate its phase relative to the other speakers in the system. Such a device is the audio phase detector presented here. The coded signal is a sawtooth waveform generated by an integrated circuit voltage-to-frequency converter (a voltage-controlled oscillator), the Analog Devices AD537. The sawtooth waveform is ideal for the code because the sloping portion of the waveform, the ramp, *A,* is low-frequency energy for a relatively long period of time, while the rise, *B,* is very fast, high-frequency energy for a short time (Fig. 1a). This sawtooth waveform is connected to the line input jack of an amplifier, amplified, and the speakers will reproduce the waveform into a sound wave picked up by a microphone on the receiver. The air mass between speaker and receiver acts like a capacitor and differentiates the waveform, (Fig. 2). The long, slow ramp (*A*) becomes a long duration, very low signal, while the fast falling portion (*B*) becomes a high amplitude spike. So in practice, the high amplitude spike can be detected, and its polarity will be due to the relative phasing of that particular speaker.

Circuit Operation

The heart of the transmitter is the Analog Devices AD537, a monolithic voltage-to-frequency converter. The AD537 was chosen because it is very stable over temperature variations and contains its own voltage reference which is used as the voltage input to pin #5. The AD537s are closely matched to one another, because of this the user does not need an oscilloscope or frequency meter, and no adjustments are required. Frequency of operation is determined by capacitor C_1 and resistor R_1, (Fig. 3). The output of the AD537, pin 14, is normally a square wave, however, for this application a sawtooth waveform is desired. This is accomplished by an RC time constant of 10 mS at the output, using resistor R_2 and capacitor C_2. The time constant is long enough, compared to the operating frequency, that the ramp of the sawtooth wave is linear. The output of the 537 is then reduced to an amplifier line input level of approximately 1½ volts by resistors R_3 & R_4. Resistor R_3 also minimizes

*Analog Devices
Norwood, MA

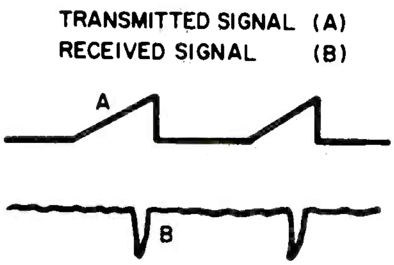


Fig. 1 — The coded signal is a sawtooth waveform.

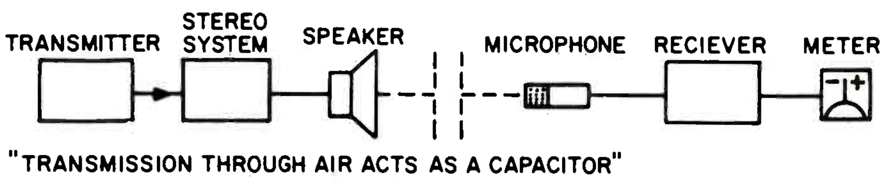


Fig. 2 — Block diagram of the detection system.

loading of the output, keeping the output waveform undistorted. Power is supplied by a 9-volt transistor radio battery.

Receiver

The receiver uses an inexpensive portable cassette recorder microphone; any dynamic microphone with a high-impedance output will also work. The microphone output is connected to J_1 and amplified by IC_1, a 741 operational amplifier with a gain of 200 (Fig. 4). The signal then runs to a dual peak detector D_1 & D_2, is filtered by C_1 & C_2, and the two d.c. signals are mixed by R_3 & R_6. The two d.c. signals are the detected ramp and the detected spike of the sawtooth waveform that was transmitted through the speaker. The spike will be much greater in amplitude and override the smaller ramp signal.

The resistors R_3 & R_6 also serve as the gain setting resistors for IC_2 in conjunction with resistor R_4. The resulting d.c. level is amplified by IC_2 which has a gain of 10 and runs to voltage divider R_7 & R_8. Resistor R_8 is an overall gain adjustment to make up for the output level variations in microphones. The meter is a miniature 50-0-50 d.c. microammeter with a 1¾ inch square outside diameter.

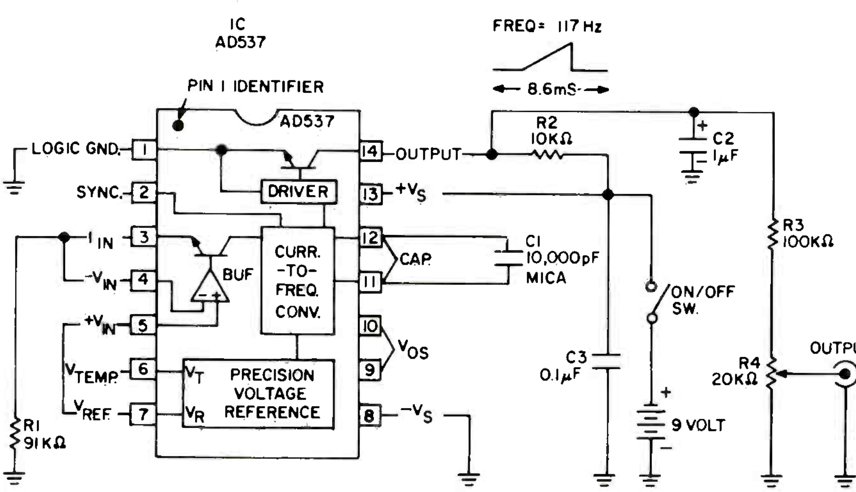
Power for the receiver is also a 9-volt transitor radio battery. Resistors R_9 & R_{10} convert the 9-volt battery output into ± 4.5 volts to ground for powering the operational amplifiers. Capacitors C_3 & C_4 assure a low a.c. impedance to ground. Jack J_2 is a differentiator input for inputs from audio lines, amplifier outputs, etc. Capacitor C_6 differentiates the input signal, instead of using an air mass.

Construction

Both the transmitter and receiver were built on small breadboards and placed in 2⁵/₈ x 4 inch miniboxes. The best boxes to use are the Model 3301 miniboxes made by Pomona Electronics Co., which can stand up to heavy duty and look professional. The power switch for the transmitter may be located at any convenient point on the minibox. On the receiver, the meter should be located near the front of the top side of the minibox. The microphone is attached to the bottom side, its front extending out about an inch from the front of the minibox.

The microphone can be attached to the bottom of the box by stick-on tie wrap anchors and tin wraps. The breadboarded circuitry for the transmitter and receiver can be placed in the miniboxes on standoffs. The cost is under $30.00.

Fig. 3 — The transmitter schematic.



Calibration and Use

Connect the output of the transmitter to the line input jack of the left channel of the stereo amplifier in the system to be phased. If more than one amplifier is used in the system, connect the output of the transmitter to the high level input of the preamplifier. Set the tone controls to *Flat* position, and turn off the loudness contour control. Turn on the transmitter, and adjust the output of the speakers to a fairly loud but comfortable level. Turn on the receiver and hold it so that its microphone is ½ to 3 inches from the speaker you wish to phase first. Adjust the trimpot, R_8 in the receiver so that the meter registers a strong indication to either the left or right of center. The direction the meter travels will depend on the relative phase of that particular speaker. Next, check all the other speakers in the left channel. They should all indicate the same direction. If any are different, reverse their leads until all the speakers in that channel cause the meter to deflect in the same direction. After the left channel has been phased, connect the output of the transmitter to the right channel and phase all the speakers in that channel so that they deflect the receiver's meter in the *same* direction as the left channel. When you are finished, all speakers in the system will be in phase.

It must be pointed out that proper operation of the phase detector is dependent on the sawtooth waveform from the transmitter arriving undistorted at the speaker terminals. Tone controls and other frequency shaping devices must be set to their *Flat* position. Loudness controls should be turned off. Electronic crossover networks should be set to flat or bypassed. If the preamplifier system can-

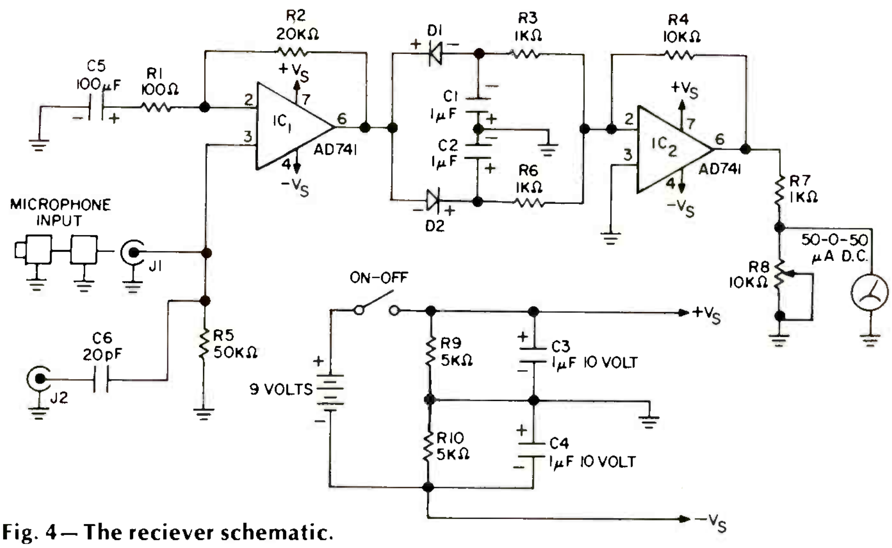


Fig. 4—The reciever schematic.

not be set for flat response or if it has no unequalized inputs, phasing should be performed by feeding the transmitter output directly into the power amplifiers.

To phase microphones, simply unplug the microphone from J_1 and substitute the microphone to be phased. They can be plugged in one at a time and held ½ to 3 inches from the speaker. They should all deflect the meter in the same direction if correctly phased. The second jack, J_2, is for phasing amplifiers, lines, and various other audio gear. The jack accepts a line level of from 0.5 to 1.5 volts.

PARTS LIST

Transmitter

C_1—10,000 pF capacitor, mica or polystyrene
C_2—1 μF, 12 V tantalum capacitor
C_3—0.1 μF paper capacitor
IC—AD537J V/F converter, manufactured by Analog Devices
J_1—RCA phono jack
R_1—91 kilohm, 5% carbon resistor
R_2—10 kilohm, 5%, ¼ watt carbon resistor
R_3—100 kilohm, ¼ watt 5% carbon resistor
R_4—20 kilohm potentiometer
1—14-pin dip socket
1—9V transistor radio battery
1—Battery clip
1—2⅝ x4x1½ inch minibox, Pomona Electronics, Model 3301
1—Single-pole, single-throw *On/Off* switch, Microswitch 8C1021
4—Small rubber feet

Receiver

C_1, C_2, C_3, & C_4—1 μF, 10V tantalum capacitor
C_5—100 μF tantalum capacitor
C_6—20 pF mica capacitor
D_1, D_2—IN4148 diodes
IC_1, IC_2—AD741J operational amplifier
J_1, J_2—RCA phono jack
R_1—100 ohm, 5%, ¼ watt carbon resistor
R_2—20 kilohm, 5%, ¼ watt carbon resistor
R_3, R_6, R_7—1 kilohm, 5%, ¼ watt carbon resistor
R_4—10 kilohm, 5%, ¼ watt carbon resistor
R_5—50 kilohm, 5%, ¼ watt carbon resistor
R_8—10 kilohm trimpot
R_9, R_{10}—5 kilohm 5%, ¼ watt carbon resistor
1—50-0-50 d.c. microammeter, International Model 163
2—8-pin TO-99 sockets
1—9V transistor radio battery
1—Battery clip
1—2⅝x4x1½ inch minibox—Pomona Electronics Model 3301
1—Single pole, single throw *On/off* switch, Microswitch 8C1021
1—Inexpensive dynamic microphone
Tie wraps and tie wrap anchors

Note:

The three ICs may be purchased by ordering: One AD537JD @ $13.00; two AD741CH @ $3.00; postage and handling, $1.00, for a total of $17.00. Send prepaid by check or money order to: Order Processing, Analog Devices, Inc., Rt. 1 Industrial Park, Norwood, MA 02062.