

BUILD AN AUDIO COMPANDER

*Provides greater dynamic range
and reduces noise.*

BY JOHN ROBERTS

PERHAPS the last frontier yet to be crossed by high-fidelity program sources is dynamic range. For example, the best consumer tape decks have a dynamic range of about 65 dB when used with premium tape formulas. Compare that to the 115-dB range of music produced by a symphonic orchestra at a live performance.

This project—a 2:1/1:2 compander—will allow you to record live music on your existing tape deck and later play it back without losing its original dynamic range. Other benefits of compansion are

increased tape headroom during record and noise reduction during playback. These advantages can be realized whether the program material is being recorded live or transcribed from another format. The compander is easy to build and use, employs a new Signatics IC, and has a low parts count. A stereo compander is available in kit form as described in the Parts List.

Compansion involves compressing a signal's amplitude before it is committed to the recording medium, and then ex-

panding it in a complementary fashion when it is recovered. This is typically accomplished by inserting a fixed-slope (2:1) compressor in the signal path before the tape deck's record preamp and a fixed-slope (1:2) expander at the output of the deck's playback preamp. The process is shown graphically in Fig. 1. Practicalities of electronic circuitry in preamps and power amplifiers limit their dynamic range to 100 to 120 dB. However, this approaches the dynamic range of live music and (comfortable) human hearing, easily attainable by a good tape deck working with a 2:1/1:2 compander.

The improvement in S/N becomes apparent when we look at a specific example. Let's assume that we have a tape deck with a noise floor of -45 dBm and that we want to record a piece of music with passages as low as -50 dBm. In the absence of any processing, the soft passages would disappear into the hiss. However, if we pass the signal through a 2:1 compressor before recording it, the minimum amplitude recorded is -25 dBm, a full 20 dB above the noise. On playback, passing the tape output through a 1:2 expander restores the -25 -dBm signal to its original -50 dBm. Simultaneously, the noise drops by the same -25 dB to -70 dBm.

Improvements are also realized in the upward direction. That is, headroom is increased. A tape that previously saturated (causing distortion) at $+10$ dBm can now handle a $+20$ -dBm signal at the compressor input. Although compansion increases S/N and headroom, it places more stringent requirements on the medium's frequency response and amplitude stability. Because the expander's gain depends on the level of the compressed signal applied to it, any amplitude errors will be magnified. In the case of a 2:1/1:2 compander, any frequency response errors or amplitude anomalies will be doubled.

A Compander IC. Signetics Corporation has recently developed an IC called the NE570. It is a dual-channel linear IC, and either section can be used independently of the other as a compressor or expander. A block diagram and pinout of the NE570 is shown in Fig.

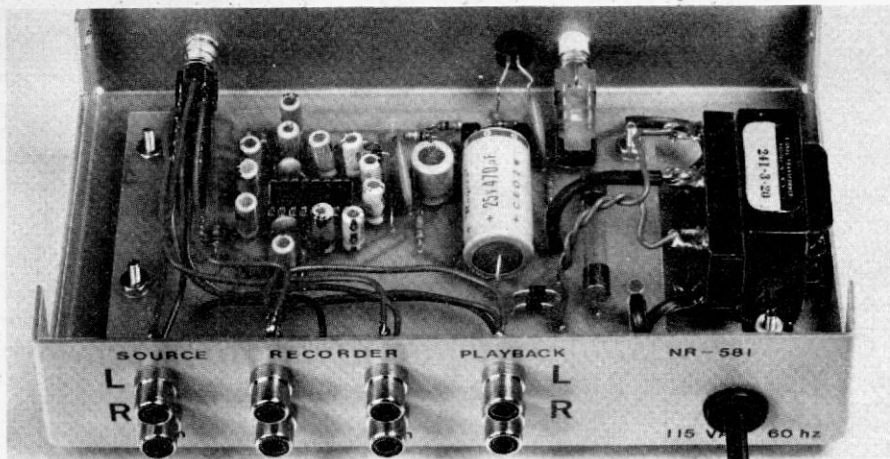


Photo shows prototype assembled on pc board and mounted in metal chassis.

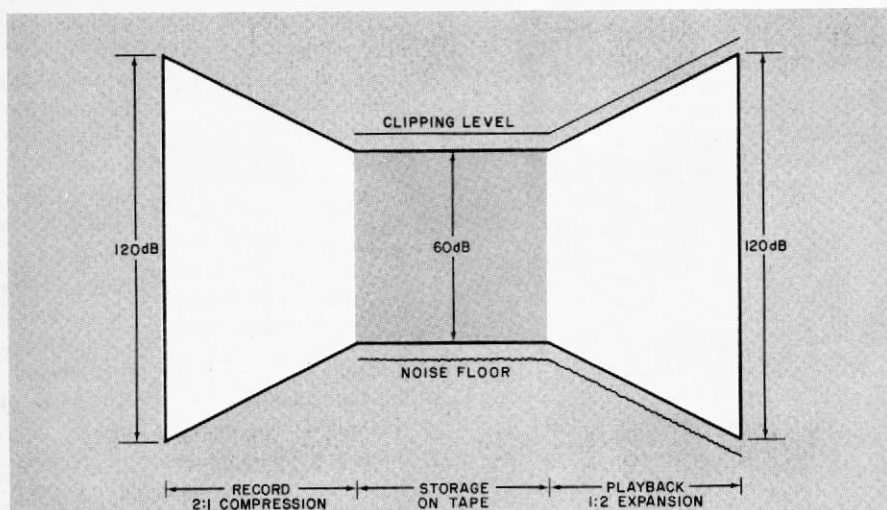


Fig. 1. Compression is used during recording, expansion on playback.

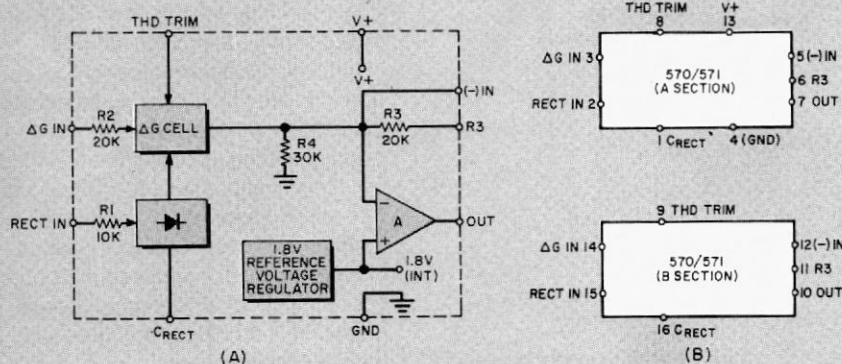


Fig. 2. Block diagram (A) and pinout (B) of the NE570 IC.

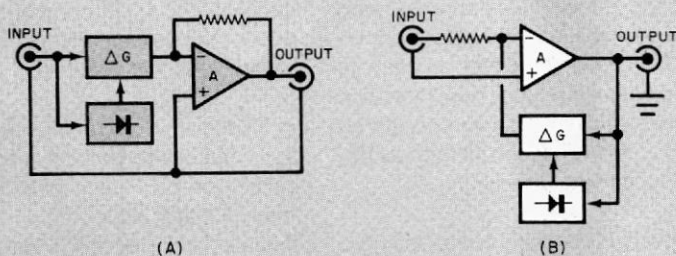


Fig. 3. Using the NE570 as an expander (A) and compressor (B).

2. Packaged in a 16-pin DIP, only the power supply and ground connections and an internal 1.8-volt bias regulator are shared by the two companders.

Each compander comprises a ΔG (variable gain) cell, a full-wave rectifier, and an output amplifier. The ΔG cell governs compander gain. Its control voltage is developed by rectifying an input signal. The output signal is generated by the op amp, which is driven by a scaled current supplied by the ΔG cell. Whether a section of the NE570 functions as a compressor or expander depends on how the basic blocks are interconnected. Typical specifications for the NE570 are in table on next page.

A 1:2 dynamic range expander (Fig. 3A) is formed by placing the ΔG cell at the input of the op amp. Its control signal is generated by sampling the input signal, rectifying and filtering it. The fixed feedback impedance sets the overall gain at unity when the input signal is 0 dBm or 0.775 volt. As the input increases or decreases from this level, the gain increases or decreases proportionally. For example, if the input level increases by a factor of two (+6 dB), the output level is quadrupled (+12 dB). If the input decreases by one half (-6 dB), the output drops to one quarter (-12 dB) of its previous value.

Rearranging the blocks to form the network shown in Fig. 3B results in a 2:1 dynamic range compressor. Here, the ΔG cell is connected as a feedback impedance, and its control signal is derived from the op amp output. The fixed input network sets overall gain for a 0-dBm signal. If the input signal level increases by a factor of four (+12 dB), the output amplitude is doubled (+6 dB). If the input amplitude is decreased by a factor of four (-12 dB), the output signal decreases by a factor of two (-6 dB).

About the Circuit. The schematic diagram of the compander is shown in Fig. 4. A conventional full-wave rectifier and RC filter supply the required operating voltages. Note that only one compander channel is shown. The components with the suffix "A" are for the channel A compander only. Integrated circuit pin numbers in parenthesis are the corresponding inputs and outputs of the channel B compander. For example, pin 1 is connected to C4A, and pin 16 should be connected to C4B.

Diodes D3 and D4, LED1, transistors Q1 and Q2, and their associated components form a level indicator. The LED glows when input signal peaks exceed 0 dBm. Switch S2 interconnects the

TYPICAL SPECIFICATIONS NE570 COMPANDER

Maximum input/output level:	+12 dBm
Maximum output current:	±20 mA
Unity gain level:	0 dBm ±1 dB
Tracking error:	±0.2 dB
Gain change with temperature (0° to 70° C):	±0.1 dB
Output slew rate:	±0.5 V/μs
THD* (compressor or expander only):	0.3%
Expander noise output (measured with input shorted):	-96 dBm "A" weighting
Frequency response;	
Compressor:	20 to 20,000 Hz, +0, -1.5 dB at 0 dBm
Expander:	20 to 20,000 Hz, +0.5, -1 dB at 0 dBm

*—Harmonic distortion is caused primarily by ΔG cell offsets and modulation of the cell by control voltage ripple. When the recorded signal is expanded by the same ΔG cell that compressed it, the distortion cancels out, leaving tape noise or tape distortion dominant. Note—a phase inversion in the record/playback path will affect the accuracy of this cancellation.

blocks of each section of the NE570 so that the IC functions as a compressor on record and an expander on playback. Pulsating dc from the full-wave rectifier is smoothed into the ΔG cell's control signal by capacitor C4A. Capacitors C5A, C6A, C8A, and C9A provide ac coupling between various parts of the compander circuit.

Construction. The compander is best assembled using a printed circuit board. Suitable etching and drilling and parts placement guides are shown in Fig. 5. When mounting electrolytic capacitors and semiconductors, be sure to observe polarity and pin basing. An IC socket or Molex Soldercons are preferable to soldering the compander IC directly to the circuit board. Use the minimum amount

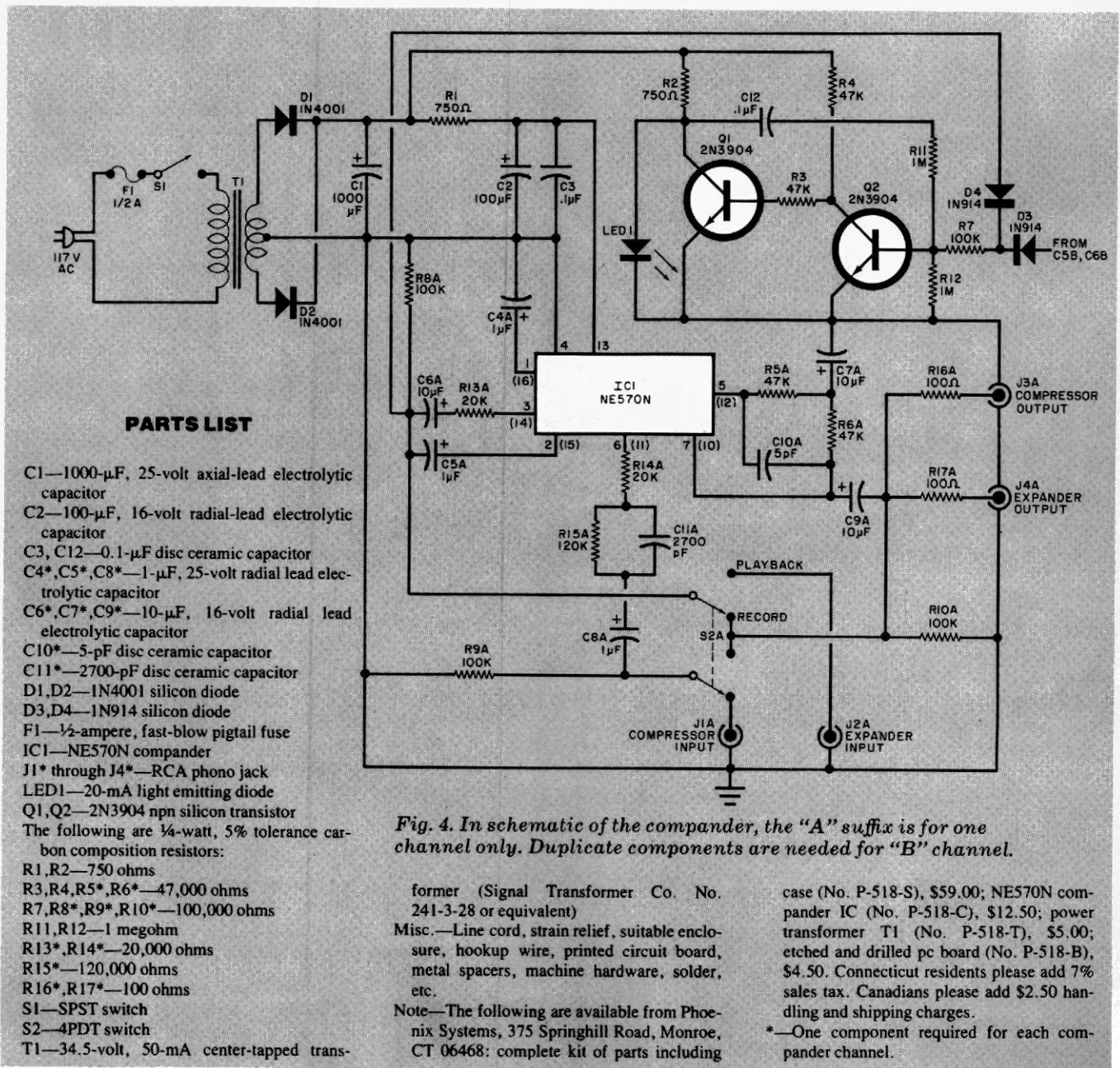


Fig. 4. In schematic of the compander, the "A" suffix is for one channel only. Duplicate components are needed for "B" channel.

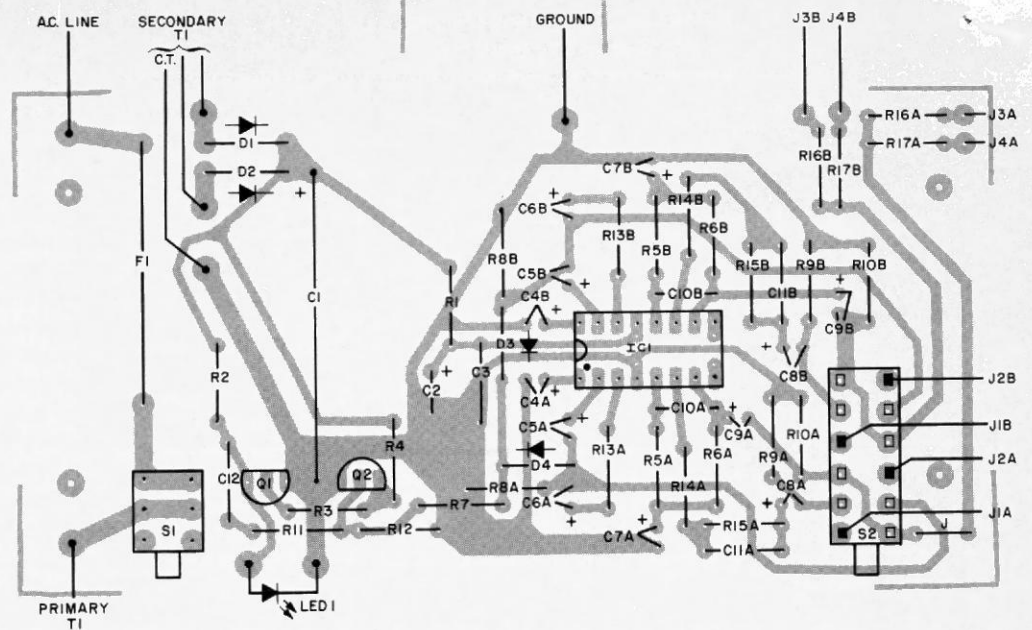
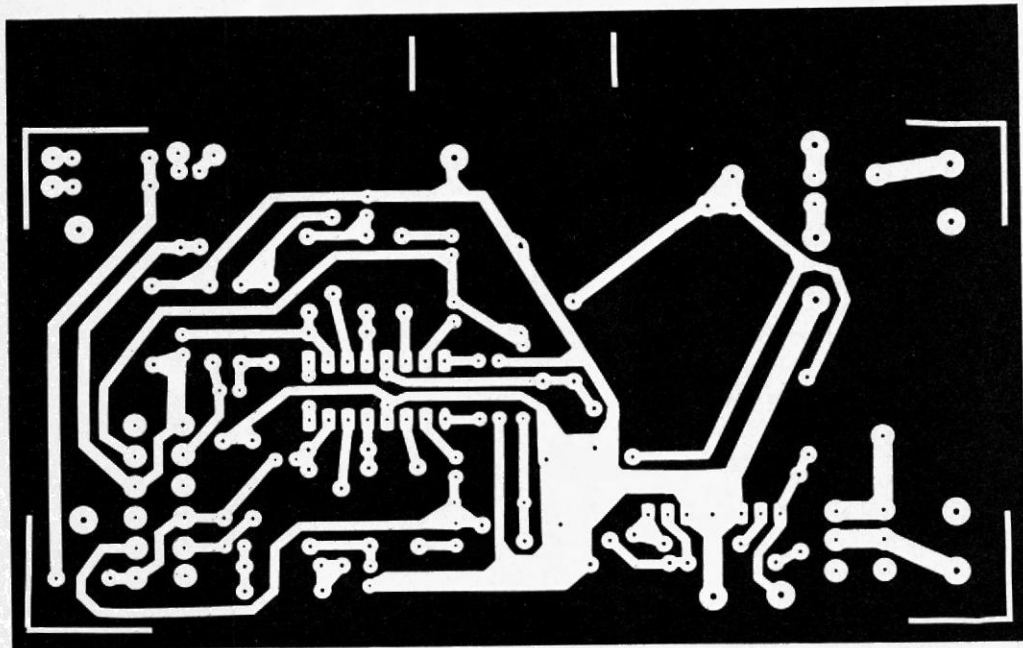


Fig. 5. Etching and drilling guide (left) and component placement (above) guides for the pc board.



of heat and solder consistent with the formation of good solder joints at each pc board pad.

If an alternate construction technique is used, care must be taken to keep all signal leads, especially those to switch S2, as short as possible. In any event,

the circuit should be mounted in a metal enclosure that is connected to the audio system ground.

Using the Componder, Interconnect each channel of the componder and your system's tape deck and amplifier

as shown in Fig. 6. Place S2 in the RECORD position and adjust the deck's record preamp level controls for a reasonable record level. With the added dynamic range supplied by the componder, you can afford to trade a few dB of the deck's S/N for reduced distortion levels. (Some tape machines are set to run very close to saturation to get the highest S/N possible.) Indicator LED1 is included not to alert you of clipping, but as an aid in setting record levels. The componder has at least 10 dB of headroom above the threshold at which the LED glows.

To play back a compressed tape, simply place S2 in the PLAYBACK position and put the deck in its playback mode. You will then retrieve the recorded program with its original dynamic range. ♦

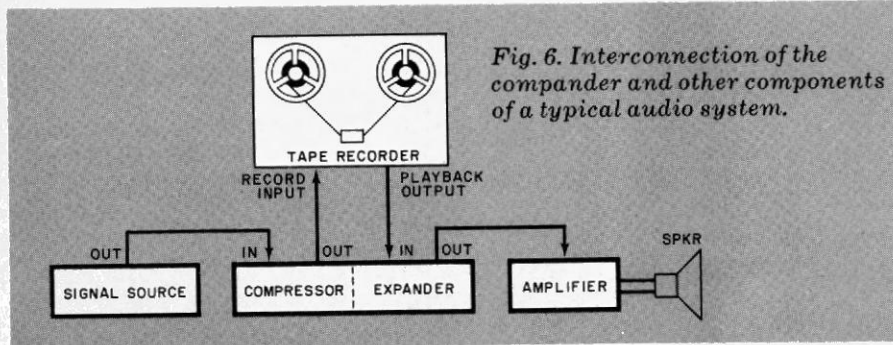


Fig. 6. Interconnection of the componder and other components of a typical audio system.