

BUILD THIS

AN AUDIO COMPRESSOR IS AN ESSENTIAL tool for audio processing and it is commonly found in recording studios. Most recording studios have a selection of compressors, each chosen for some specialized feature or nuance. Your home may not be a professional recording studio, but you do need our Stereo Compressor, so read on.

As the device's name implies, the Stereo Compressor compresses or limits the dynamic range of an audio signal. (Make sure you read the sidebar *How Compressors Work*.) In a recording studio, compressed audio prevents tape-recorder overload during loud passages without losing quiet passages in the noise floor (hiss). Before compressors were invented, the recording engineer would ride the gain by manually adjusting the signal level. Compressors are commonly used to record vocalists and acoustic instruments, especially those that have large dynamic ranges. Compressed audio can also be used to create artificial effects while recording, such as increasing the apparent sustain of an instrument or completely squashing the level of a signal. We will learn how to accomplish these audio effects later.

Compressors can also be abused. Have you ever wondered why TV commercials sound louder than regular TV programming? Well, the producer of the offending TV commercial has used a large amount of compression on the audio tracks and then boosts the gain to just below distortion level. The end result is an apparent increase in loudness to the listener. This works because modern TVs and home theaters have a large dynamic range for the audio signal.

Film and TV producers take advantage of the dynamic range available to them by recording normal conversation and background sounds 6 to 12 dB below the maximum signal level. Then for dramatic effect, music and sound effects such as explosions can be that much louder than the dialogue track. This is very noticeable when watching

Designed to lower the audio blasting that goes with TV-commercials, the unit also serves as a studio sound manipulator!

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a movie on a high-fidelity video tape recorder. In fact, for late-night viewing, when you are trying to be quiet, you have to turn the TV up just to hear the dialogue and then quickly turn it down when the car chase scene comes crashing into your living room. But, with the Stereo Compressor, you don't need to constantly ride the gain. It will automatically do that for you!

When you patch the Stereo Compressor between your hi-fi VCR and your stereo sound sys-

tem, you can enjoy listening to movies late at night in full fidelity, at low volume, without being blasted out of your chair when Rambo raids your living room. You can also use the unit to prevent tape (recording) overload while making home audio recordings.

How it is done

The block diagram of the Stereo Compressor is shown in Fig 1. The input signal is fed to a voltage-controlled amplifier

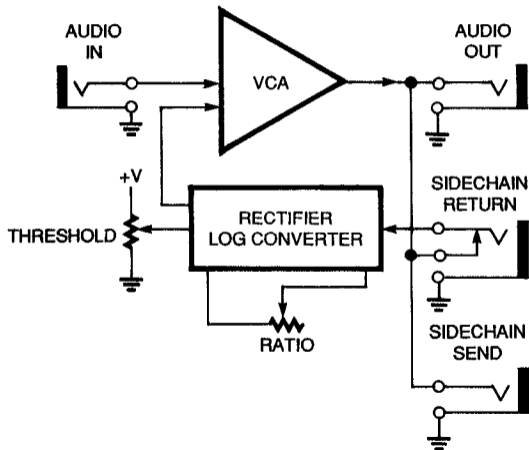


FIG. 1—FUNCTIONAL BLOCK DIAGRAM of the Stereo Compressor. Side-chain portions of the diagram may be omitted from the unit's construction.

(VCA) that has a nominal gain of unity. Some of the output signal is fed to a precision rectifier followed by a logarithmic converter circuit. The output of this block is a DC voltage proportional to the log of the average level of the input signal. By sending some of this DC control voltage to the VCA we automatically reduce the gain of the VCA when the input signal exceeds a user-determined threshold level. It is important to note that we determine the signal level after the VCA and not before. This allows the output level to increase and sound normal, but not increase as much as the input signal does. By varying the amount of feedback we adjust the compression ratio, which in conjunction with the THRESH control, determines the operating characteristics of the compressor.

The optional *sidechain* jacks permit external processing of the audio signal or substituting a completely different audio signal as the control signal. This add-on circuitry lets the user experiment and achieve some useful audio effects.

How it works

Figure 2 is the schematic diagram of the Stereo Compressor. The device has two independent channels of compression, right and left. The heart of the circuit is the SSM2120 dual dynamic range processor integrated circuit IC3. The SSM2120 features two complete dynamic range pro-

cessors. Each one consists of a voltage-control amplifier, a logarithmic converter, and a precision rectifier. The chip also features a dynamic range of 100 dB at only .01-percent total harmonic distortion at +10 dB input. The remainder of the Stereo Compressor circuit consists of input and output buffers, the control circuitry and the comparator.

Since the electronics for both channels is identical, we will look at the right channel in detail. The input audio signal from J1 goes to an inverting buffer circuit consisting of R40 and R44 and IC1-b. Its output signal (IC1-b, pin 7) is coupled to the signal input on IC3, pin 8, via C4, which blocks any DC component of the input signal. The SSM2120 chip is actually looking for a current input source, and R43 provides the proper amount of current to the chip. The RC filter formed by C8 and R18 eliminates any stray RF interference.

The output signal from the internal VCA of IC3 (pin 4) is actually a current signal. It is restored to a voltage signal by current-to-voltage converter IC1-a and its feedback resistor R46. The signal from IC1-a, pin 1 is routed to output stage amplifier IC5-a via R34. The output signal from IC5-a, pin 1, is coupled via R35 and C9 to jack J3. OUTPUT potentiometer R55 lets you adjust the unit's gain.

The output signal is also sent to the rectifier input (IC3, pin 9) via R36 and C7 either directly,

or via the optional side-chain jack circuitry including R50. The side-chain jacks consist of a standard 1/4-inch open-circuit _{OUT} phone jack (J7) and a 1/4-inch _{IN} phone jack (J8) with a normally-closed switch built into them. These jacks form a normalized patch point for additional audio processing. With nothing plugged into J8, the signal path is uninterrupted. By inserting a phone plug into the side-chain _{IN} jack (J8), the normal signal path is broken and either the processed original signal is sent to the rectifier input, or a completely different (new) signal is sent to the rectifier input. We will later see how to use this feature for some really powerful audio processing.

But first, the control side of the house. Resistor R22 provides a reference current to the log-averaging circuit within IC3 via pin 2. It also forms an RC timing circuit with C5. This RC circuit determines the response time for the compressor. The time constant is set so that the compressor will respond rapidly without distorting.

Potentiometer R51 along with other resistors, develops the threshold level signal. The voltage from the wiper of R51 is sent to the threshold input of IC3 (pin 1) via R42. Another resistor R41 across the threshold pin 1 and the control output pin 3 establishes the internal gain of the control stage. The control output signal from pin 3 goes to a voltage-divider network centered around potentiometer R53 then to the inverting VCA input of IC3 (pin 7). A positive voltage on this input reduces the VCA gain, which is what we need to make the compressor work. Note that both the inverting and non-inverting control inputs (pins 5 and 7) are tied to ground via R5 and R7. The control inputs must remain close to ground potential for proper operation. A 6-millivolt change in voltage at these control pins causes a 1 dB change in VCA output. Diodes D6 and D7 ensure a unipolar control voltage. Potentiometer R53 is the compression _{RATIO} control. It gives

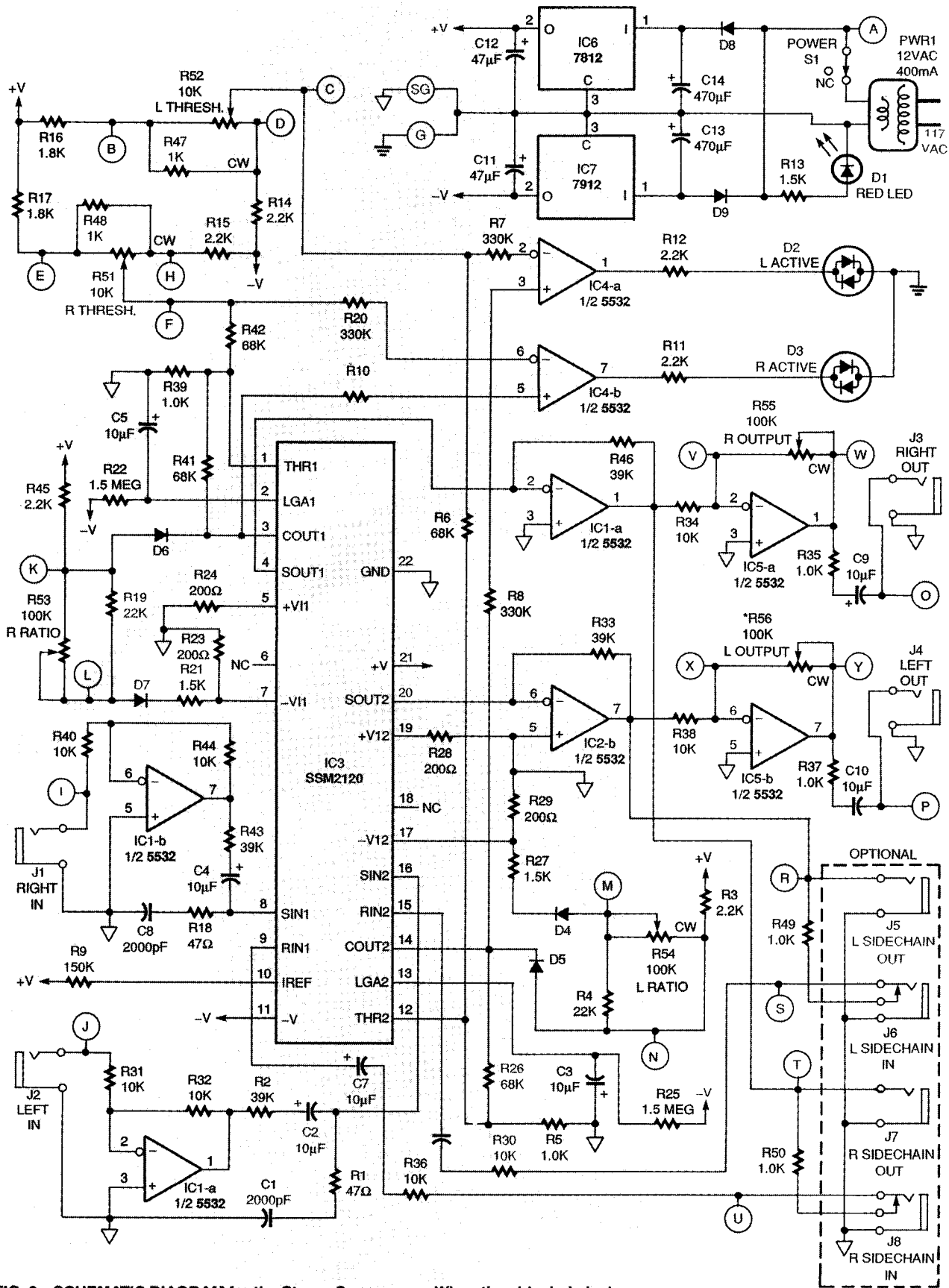


FIG. 2—SCHEMATIC DIAGRAM for the Stereo Compressor. When the sidechain jacks are included, the unit is designated as the Stereo version by PAIA. The Home Theatre version eliminates the jacks.

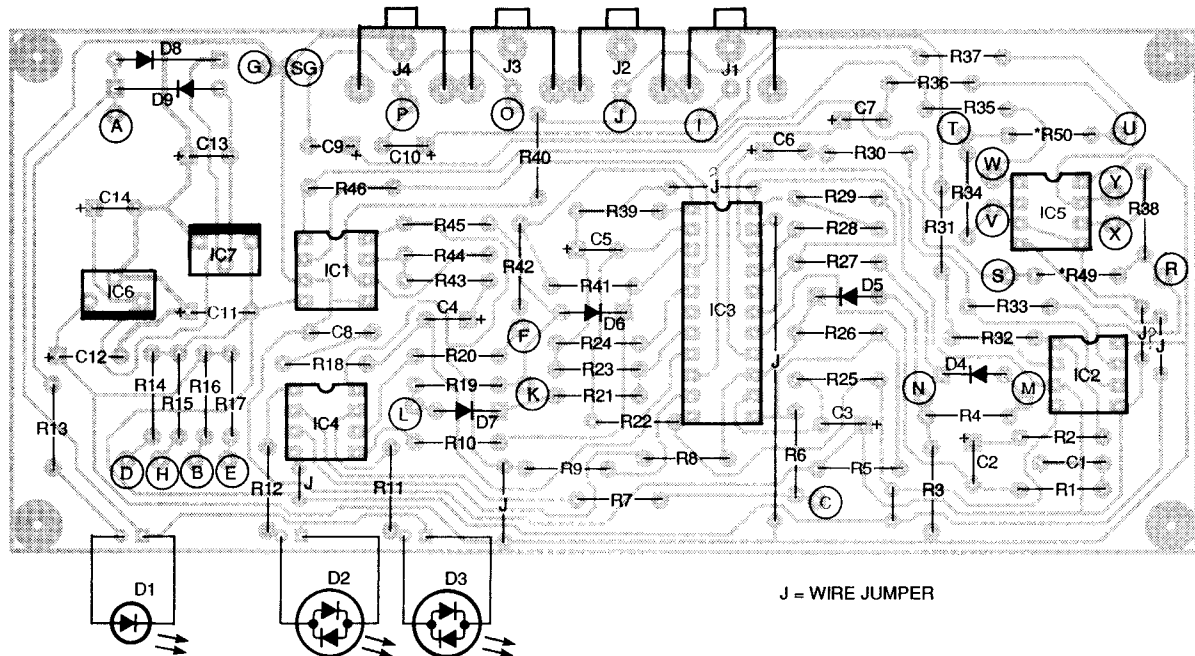
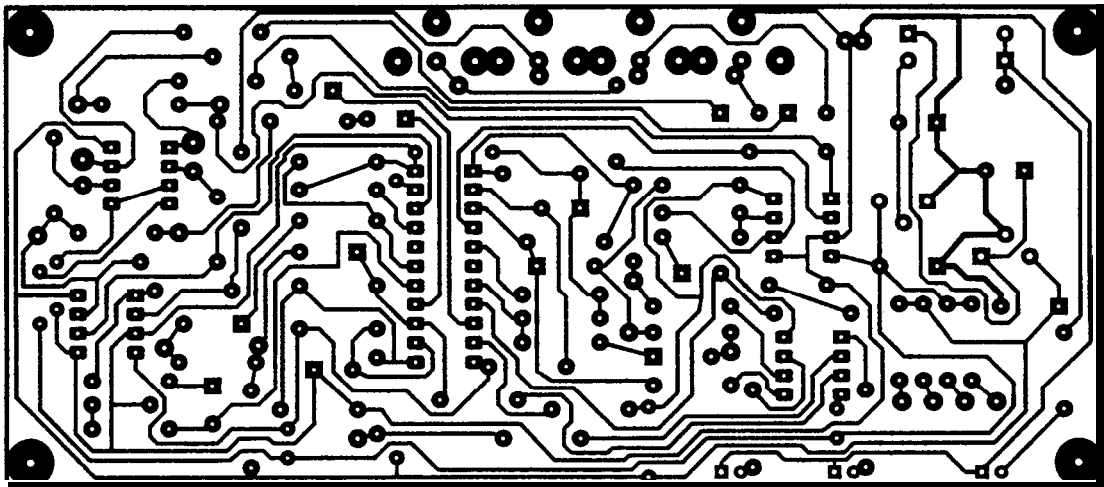


FIG. 3—PARTS PLACEMENT on the PA1A PC board. The silk-screen markings on the board provide an additional assist for the assembler. Resistors R49 and R50 are shown in place for the Home Theatre version. The studio version of the Stereo Compressor has these resistors mounted on jack terminals.



BOTTOM VIEW of the PC board, shown same size, details the foil pattern home-brew experimenters must assemble.

an adjustable compression ratio of 2 to 1, all the way to about 25 to 1.

The last portion of the circuit is the comparator formed by IC4-b, two input resistors R10 and R20, a bicolor light-emitting diode LED3, and current limiting R11 for the light-emitting diode D1. Notice that op-amp IC4-b is a comparator. Normally it is unwise to use an op-amp for this purpose because the output stage saturates,

which will slow down the comparators response time. (Note: D1 through D3 are light-emitting diodes or LEDs. This symbol identification code was used in this story in order to agree with PAiAs kit symbolism.) In this instance, we need to get an output that changes from one supply rail to the other. This makes dual-LED interfacing very simple. Along with being an excellent audio op-amp, the NE5532 functions well as a

comparator in this application.

The power supply circuit consists of an externally connected Wall-Wart 12-volt AC transformer PW1 and associated diodes and capacitors. (See top-right corner of Fig. 2.1 One side of the 12-volt AC line is tied to ground and the hot side goes to half-wave rectifiers D8 and D9. These diodes deliver bipolar, unfiltered DC, and each supply is filtered by electrolytic capaci-

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STEREO COMPRESSOR

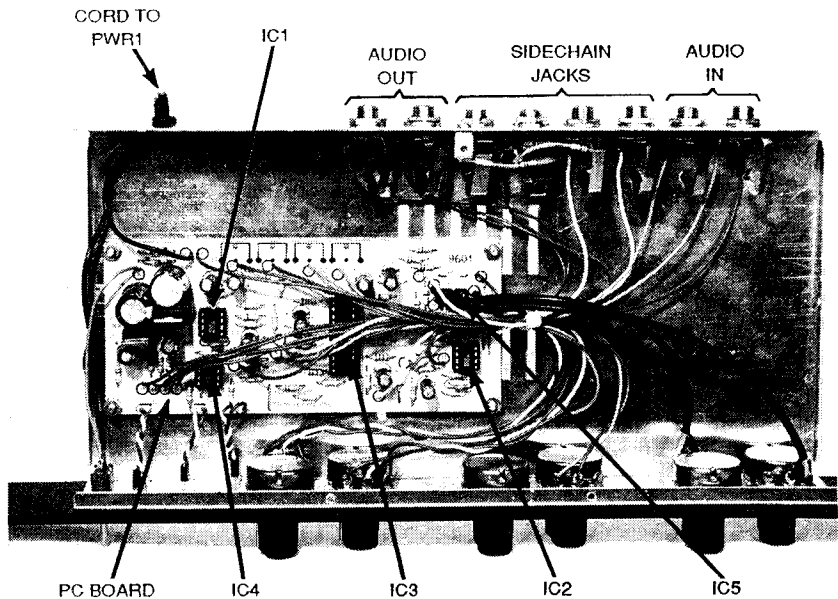
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tors C13 and C14. Even though PWRL is rated at 12-volts AC, the filter capacitors charge closer to the peak value of the 12-volt AC, and just about 15-volts DC is delivered to the + 12-volt DC regulator IC6 and -12-volt DC regulator IC7. The output of each voltage regulator section is filtered for decoupling purposes by electrolytic capacitors C11 and C12.

Two ground systems are used in the Stereo Compressor, one for power return and the other for signal return. This design practice reduces the possibilities of ground loops that introduce unwanted AC hum to the audio signals.

construction

Assembly of the Stereo Compressor is relatively straightforward. PAiA Electronics has complete kit of parts available for the Home Theatre version (no sidechain jacks) and the Studio version (includes sidechain jacks). If you want to roll your own, the circuit can be built on a Radio Shack experimenters PC board or you could copy the same-size drawing of the circuit board provided in these pages and make your own



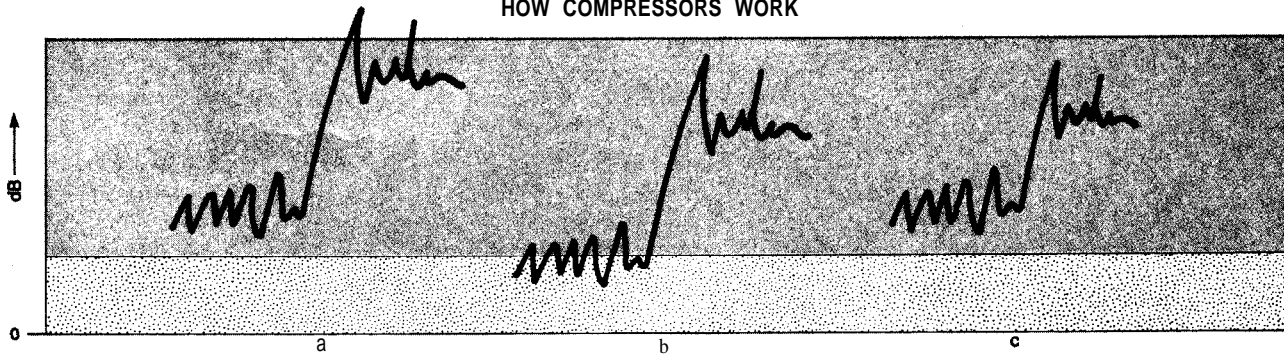
BIRD'S EYE VIEW of the Stereo Compressor before the chassis cover is secured in place. Note the neat interconnection between the PC board and front and rear panels.

board. The SSM2120 chip (IC3) is available from several sources including PAiA, Newark and Allied. The other parts are common garden variety types available from local and mail-order parts suppliers. If you do breadboard the circuit, make certain you use good grounding techniques. Return all signal and power grounds to one common point to eliminate any ground loops. Should you elect to use the PAiA circuit board, the circled letters in Fig. 2 are termina-

tion-point identifiers for hookup wires that run from the front and rear panel-mounted parts to the PC board. These interconnections are shown in Figs. 3 and 4.

The three light-emitting diodes D1 through D3 require lead extensions made from #22 insulated hookup wire. Mark the leads so that you can readily identify the anode and cathode terminals. Twist the leads of the LEDs and cut their length so that the LEDs will fit into the

HOW COMPRESSORS WORK



The gray band is the usable dynamic range of a quality audio tape. The dotted band below the gray band is the inherent tape noise (hiss) common to all tapes. The range (height) of these bands varies with tape quality. The audio signal in (a) shows a loud passage that is too loud

for the listener, so the volume was turned down (b) to lower the loud passage in the tape's dynamic range. However, the quiet passage was lowered into the noise band common to all tapes. The quiet passage is either lost in the hiss or will sound appalling when played

back. A compressed audio signal of the same passage (c) permits the quiet passages to be recorded above the hiss in the tape's usable dynamic range while the loud passage is reduced in volume for the listener's pleasure.

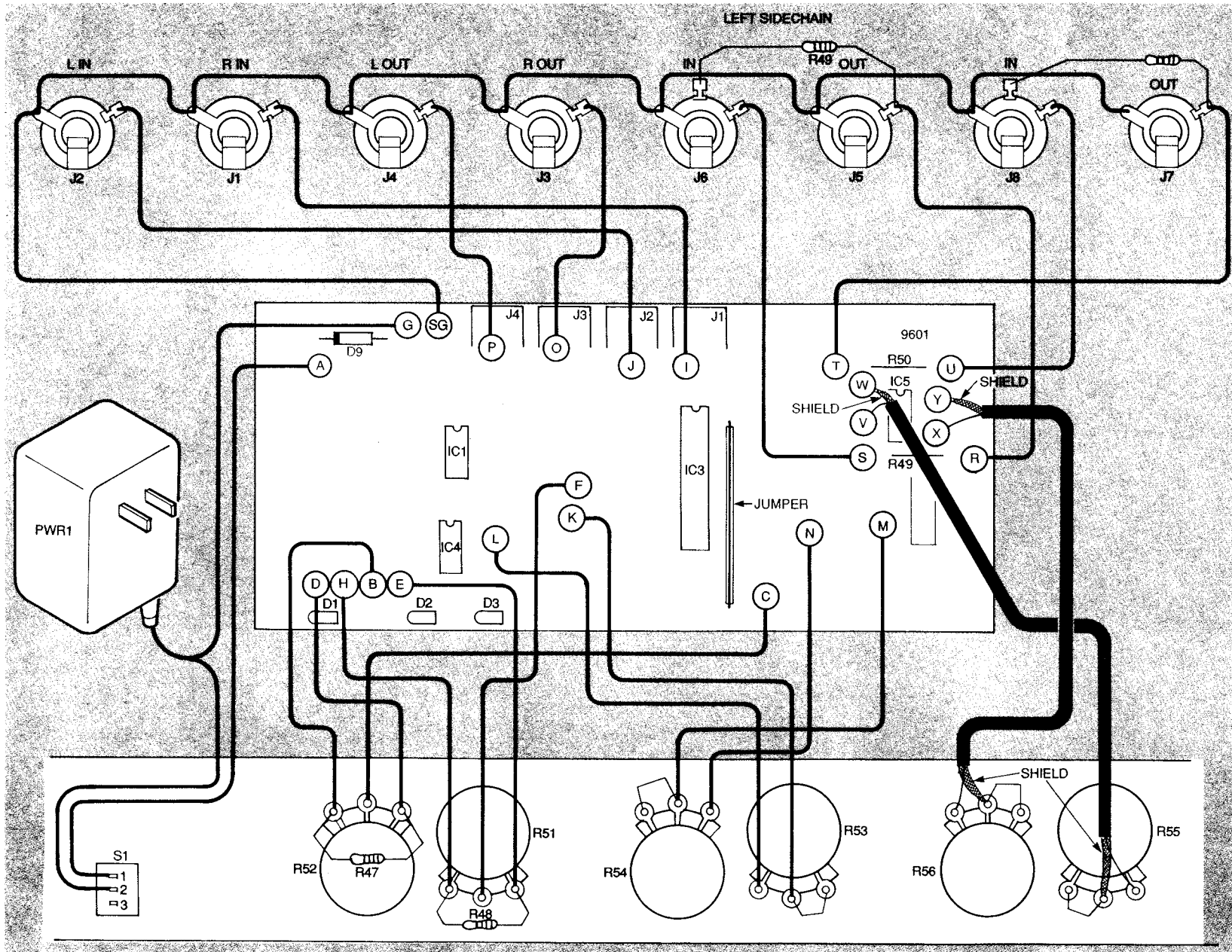


FIG. 4—INTERCONNECTING THE PC BOARD with the front and rear panel parts is simplified by PC board circled markings. The long cable runs from the board's output stage to two front-panel controls, which requires using thin, flexible, audio, coaxial cables such as the RG-174/U type. The unit's step-down power transformer PWR1 is contained in a wall-plug casing that plugs into a power outlet.

three holes provided for them on the front panel. These holes are between the **POWER** switch **SI** and the **THRESH** potentiometer **R52** (See Fig. 4).

If you choose to omit the side-chain option (A big mistake-Editor), eliminate jacks **J5** through **J8**. Resistors **R49** and **R50** normally mount on the terminals of jacks **J5** and **J7**. When the sidechain jacks are omitted, these 1000-ohm resistors are connected to terminals **R** and **S** and **S** and **T**, respectively, on the PC board.

The light-emitting diodes (**D2** and **D3**) combined ground path must return straight to the

power supply common. The LED's comparatively high current that is switching on and off in this ground return could cause popping sounds in the audio output when connected to signal or even power grounds.

Testing

After you have wired the Stereo Compressor, check for solder bridges, cold-solder joints, incorrect component polarities and all the other nasty errors that prevent a circuit from functioning normally and sometimes result in self-destruction. Do this before applying power!

The best way to test the Stereo Compressor is to connect it between a CD or cassette deck and your hi-fi audio system. Set the **RATIO** control (**R53**) fully counter clockwise and the **THRESH** control fully clockwise. Set the **OUTPUT** control to about ten o'clock. These are the minimum settings. You should hear undistorted, noise-free audio. Both LEDs (**D2** and **D3**) should be green. If there is distortion or noise, you need to go back and check your wiring and component polarities. If everything sounds good and you have green LEDs, then everything should be working fine. Note: with no input signal the LEDs may drift slightly and not track the **THRESH** control.

Once everything is working, slowly rotate the **THRESH** control. At some point around mid-rotation, the LEDs should start to indicate red. This means compression is starting to occur. Rotate the **RATIO** control clockwise. You should hear a decrease in volume as the compressor squashes the signal. At full counterclockwise rotation there might be some distortion. This is to be expected.

Using the compressor

The main use for a compressor is to keep levels from getting out of control while recording vocals and acoustic instruments. This takes a little experimentation. For avocalist I usually start out around a 4-to-1 compression ratio with the **THRESH** set so the LED indicates red when the singers reach their nominal level. This way if they hit a note 20 dB higher than nominal (which would definitely clip most tape decks) the signal out of the compressor only increases by about 5 dB.

The Stereo Compressor can increase the apparent sustain of a sound. By using a large amount of compression and restoring the level with the **OUTPUT** control, the compressor will initially reduce the output signal by a large amount. As the input signal level decreases, the amount of compression will decrease and the output level will

PARTS LIST

All fixed resistors are s-watt, 5%.

R1, R8-47-ohms
R2, **R33**, **R43**, **R46**-39,000-ohms
R3, **R11**, **R12**, **R14**, **R15**, **R45**-2200-ohms
R4, **R9**-150,000-ohms
R5, **R35**, **R37**, **R39**, **R47**-**R50**-1000-ohms
R6, **R26**, **R41**, **R42**-68,000-ohms
R7, **R8**, **R10**, **R20**-330,000-ohms
R9-150,000-ohms
R13, **R21**, **R27**-1500-ohms
R16, **R17**-1800-ohms
R22, **R25**-1.5-Megohm
R23, **R24**, **R28**, **R29**-200-ohms
R30-**R34**, **R36**, **R38**, **R40**, **R44**-10,000-ohms
R51, **R52**-10,000-ohm panel-mount potentiometer
R53-**R56**-100,000-ohm, panel-mount potentiometer

Capacitors

C1, **C8**-2000-pF, ceramic disk
C2-**C7**, **C9**, **C10**-10- μ F, 16-volt, electrolytic
C11, **C12**-47- μ F, 16 volt, electrolytic
C13, **C14**-470- μ F, 25 volt, electrolytic

Se&conductors

IC1, **IC2**, **IC4**, **IC5**-5532 dual low-noise op-amp
IC3-SSM2120 dynamic range processor
IC6-7812 + 12-volt regulator
IC7-7912 -12-volt regulator
D1-Light-emitting diode, red
D2, **D3**- Light-emitting diode, bi-color, red and green
D4-**D7**-1N4148 silicon signal diode
D8, **D9**--1N4001 silicon power diode

Miscellaneous

J1-**J4**-Jack, RCA-phono, PC-mount (Home Theatre version only)
J1-**J5**, **J7**- Jack, 1/4-in., mono-phone, panel-mount (Studio version only)
J6, **J8**-Jack, t/a-in., mono-phone, closed-circuit, panel-mount (Studio version only)
PWR1-Wall-Wart 12-volt AC transformer
PC board, wire, audio coaxial cable (see text), knobs, hardware, case, solder, etc.

The following are available from PAIA Electronics, 3200 Teakwood Lane, Edmond, OK 73013. Tel: 405-340-6300. FAX: 405-340-6378. Email: <http://www.paia.com>.

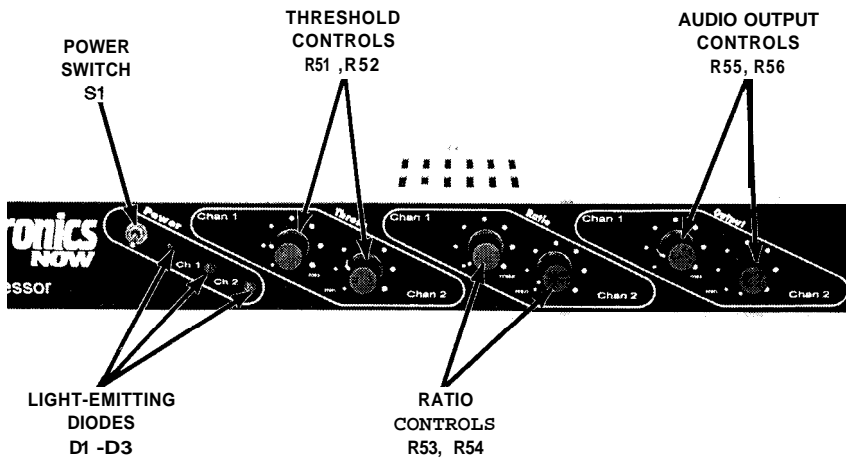
Complete kit of electronic components including circuit board, knobs, wall-plug transformer, phone jacks, etc., but less case-US\$74.75 #9601 K

Home Theatre desk-top case, punched, anodized, legended, with wood end caps and hardware-US\$19.25 #9601DTC

Studio rack-mount case, standard 19-in. wide, 1-3/4-in. high, punched, anodized, legended front panel. Includes 1/4-in. jacks and all hardware-US\$29.50 #9601RMC

Please add US\$7.00 for shipping and handling for kit orders in the USA.

PC 'board only-\$22.50 #9601PC (shipping prepaid)



FRONT PANEL view of the Stereo Compressor. Since the unit can be used in the recording studio, channel reference is made to 1 and 2 instead of LEFT and RIGHT, respectively.

remain relatively constant. The Beatles used this on the final piano chord in A Day In The Life to make the sound linger on.

To use the compressor as a limiter while recording, set the **RATIO** to about 20 to 1 and set the **THRESH** control so that the LEDs momentarily change from green to red on peak signals. This will preserve as much dynamic range as possible.

When the Stereo Compressor is connected to a hi-fi VCR for late night viewing, set the **RATIO** control as high as possible without distorting and set the **THRESH** control to change the LED's color during quiet spoken passages. This will allow you to preserve the fidelity and stereo spread of the movie sound track, hear all the dialog, but not get blown out of your seat when the F-114 does a strafing run in your living room. The above settings are intended to be starting points, so feel free to experiment.

Using the sidechain jacks

Along with regaining control of your hi-fi VCR, there are all sorts of useful functions available via the side chain jacks. By patching an audio processor in the sidechain jacks, all sorts of cool things are possible. One of the most useful is creating a de-esser. This is a device used to remove sibilance from vocals. Sibilance is that nasty Shhhh sound that occurs when S words are spoken or sung, be-

cause of the way S sounds are formed in the human vocal track.

When we form an S sound, air passes between the teeth and tongue forming a burst of white noise and a short blast of air. If the speaker or vocalist is close to the microphone, this is picked up as a brief overload and noise burst. This burst of sound mostly contains high frequencies. By setting an equalizer to boost high frequencies and patching it into the side chain, the compressor will drastically compress the signal when the high frequencies are present, but act normally when they are not.

You cannot eliminate sibilance, but it can be minimized with a de-esser. Any equalizer will work. The best way to figure out what frequencies to boost is to listen to the audio through the equalizer. Start boosting until you have noticeably increased the sibilance. Anything above 3 kHz usually works; you may have to experiment. A similar problem, although at the other end of the audio spectrum, relates to P and B thump sounds. These can be minimized the same way by boosting the offending bass frequencies (less than 300 Hz) via the sidechain.

Another abuse of a compressor is to totally squash an individual instrument signal, then restore its level. This is done with vocals, snare drums,

kick drums, etc. U2 does this on a lot of their recordings. By squashing instruments that have a percussive quality (such as drums or slap bass) the amount of percussive attack is increased. This occurs because the compressor does not respond instantly. The initial attack transient portion of the signal gets through the compressor unaffected while the remainder of the signal is compressed normally. The end result is overall increase in the percussive quality of the processed sound.

The Stereo Compressor can also be used as a *ducker*. A ducker is a device that reduces one signal's level based on a different signal. This effect gets used a lot on radio commercials. In this case, a different audio signal is fed into the side chain such as an announcer's voice. When the announcer speaks, the output of the compressor is reduced. This is useful for keeping background music at maximum volume, but letting the announcer's voice cut through the background music by reducing the music level when the announcer speaks. Listen closely to any radio commercial and you will notice this effect. Duckers are also great for D Js or a presentation with background music.

This ducker effect is also used in the studio to allow one instrument to cut through on a mix. If you want a particular instrument to be more noticeable, such as a snare drum, send the snare signal into the sidechain and have the rest of the mix feeding the compressor normally. When ever the snare drum plays, it will reduce the level of the main mix, increasing the presence of the snare drum without increasing its level. Just by adding a fewjacks, we have increased the power of an already useful tool.

The Stereo Compressor is a state-of-the-art audio processor. It can be used to upgrade your home recordings, as an addition to a professional recording studio, or it can just allow you to enjoy late-night movies without riding the gain. Enjoy!

Non-Stereo Compressor

I would like to share my thoughts about the article, “Build a Stereo Compressor” (*Electronics Now*, August 1996). Although the two-channel compressor project will prove to be a fine addition to someone’s audio-processing needs (Analog Devices makes great, innovative ICs), it is not a stereo compressor.

For the unit to operate in the stereo mode, both rectifier log converters from channels one and two would need to be summed into a single control voltage that would then feed directly to the VCAs of both channels in a strapped configuration, thereby preserving correct stereo imaging. By that I mean that any high-level peak appearing in only one channel will cause an equal amount of gain reduction in both channels, keeping the left/right balance correct.

Any two-channel processor, when connected to a stereo signal (i.e., complete mix), would process the left and right channels independently. If a sudden loud signal appeared in only one channel, such as a lead instrument that was panned hard left or right within a total stereo mix, only that channel's VCA would respond, causing the overall level in that channel to decrease. That decrease in level to only one channel will cause image shifting. All mono information (bass drum, bass guitar, etc.) would sound off-center from the original mix.

As a two-channel compressor, I'm sure the unit will be a wonderful addition to an effects rack. As for stereo compressing a final mix, say from CD or DAT to a cassette format-no way!

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