SAP ZAPPED

In his February "Video News" piece on multichannel sound, David Lachenbruch forgot one important thing: The average consumer cannot operate a stereo TV set.

WRC-TV channel 4 (Washington, DC) rebroadcast NOAA weather audio on their SAP channel as a public service. After two days the SAP channel was turned off. The switchboard had been inundated with calls and the FCC reported that they had several hundred calls complaining of interference on channel 4.

The station then ran an endless tape loop explaining that the SAP channel was selected and the viewer should consult his owner's manual for instructions on how to return to program audio. Again the phone calls poured in. Some viewers even insisted that the station send someone to "fix" their TV sets.

Finally, after three or four weeks, the calls began to taper off. At that point, the station began to broadcast NOAA audio again. The phone calls returned, in increasing numbers each day. After a week, the SAP channel was turned off for good.

I suspect that the SAP channel will never be used for anything other than regular-programming audio.

ROBERT FUTSCHER
Alexandria, VA

TOD T. TEMPLIN

STEREO TV DECODER

Build your own high-fidelity MTS decoder for the finest in TV enjoyment.

A RECENT SURVEY OF TELEVISION STAtions across the U. S. and Canada reveals that more than 250 stations are now transmitting MTS stereo TV sound. So chances are good that at least one station in your area is transmitting stereo audio right now. You might think that you need a stereo TV or VCR to enjoy MTS, but consider this: For about $50 (for all new parts), you can build our add-on converter, which will work with virtually any TV or VCR. All components are readily available, and we've designed a PC board, which simplifies construction greatly. The circuit may be aligned by ear, although using an oscilloscope will give more precise results

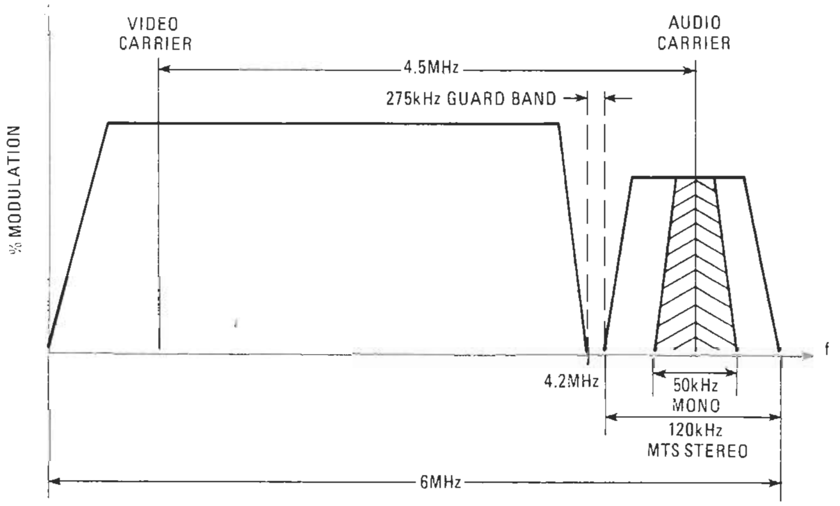


FIG. 1—STEREO-TV AUDIO requires about twice the bandwidth of a mono signal.

Background

To understand how we can enjoy MTS sound, let's look back to when color-TV standards were formed. In 1953 the NTSC (*N*ational *T*elevision *S*ystems *C*ommittee) defined the standards for color-TV broadcasting that are now used in the U. S., Canada, Mexico, and Japan.

In the NTSC system, 6 MHz is allocated for each television channel, as shown in Fig. 1. Video information is transmitted on an amplitude-modulated carrier that extends about 4.2 MHz above the visual carrier. Mono audio is transmitted on a frequency-modulated carrier 4.5 MHz above the video carrier, with 100% modulation causing a 25-kHz deviation of that carrier. So a fully modulated mono signal causes the carrier to vary between 4.475 and 4.525 MHz around the carrier.

By subtracting 4.2 MHz (top of video) from 4.475 MHz (bottom of audio), we find that there is 275 kHz of unused spectrum. That space was originally allocated as a guard band by the NTSC. The reason the guard band was necessary was that the tube-based circuits of that era were less capable of keeping the audio and the video portions of the signal separate than modern solid-state circuits. It is that 275-kHz gap that allows us to have MTS sound today.

On March 29, 1984, the BTSC (the *B*roadcast *T*elevision *S*andards *C*ommittee, which is the present-day equivalent of the NTSC), proposed guidelines to the FCC (in BC docket 21323) for TV stations using the BTSC system of multichannel sound transmission. That docket contains general technical rules governing the use of the television audio baseband for use in the transmission of stereo television sound, as well as a second-language channel (SAP, for *S*econd *A*udio *P*rogram), and a professional channel. (The alternate services were discussed in "Stereo Audio for TV," **Radio-Electronics,** February and March 1985, and in "Stereo TV Decoder," in the March 1986 issue of **Radio-Electronics.**—*Editor*)

As in the NTSC system, the baseband mono audio signal (which is the equivalent of the L+R stereo signal) has a bandwidth of about 15 kHz. It is transmitted with 75 μs of pre-emphasis, and has a maximum deviation of 25 kHz.

At 15.734 kHz is the BTSC pilot tone. The pilot is locked to horizontal sync, and it is used to identify the signal as a BTSC transmission, thus informing the television receiver to switch from mono to stereo reception. The pilot has a 5-kHz deviation.

Then comes the stereo difference signal (L−R). It is amplitude modulated on a 31.468 kHz subcarrier, producing a double-sideband suppressed-carrier signal that spans about 30 kHz. That subcarrier frequency was chosen because it is exactly twice the NTSC horizontal sweep frequency, and is, therefore, easily synchronized during both transmission and reception.

NOISE REDUCTION

THE STEREO DECODER DESCRIBED IN THIS article doesn't use a true dbx decoder. When we first decided to build an MTS decoder, we contacted the engineers at dbx Corporation in an attempt to obtain engineering samples of their decoder IC's. As you may know, however, dbx Corporation does not sell those IC's to unlicensed persons or companies, and that includes hobbyists. We were discouraged, but decided to go ahead and build a converter without the dbx IC's, and see just how well it could be done.

The decoder presented here is the result of that effort, and we believe that it performs as well as many commercial units. In addition, none of the electronic components used are difficult to obtain. Also, due to a very flexible design, you can interface the decoder to almost any TV or VCR and obtain very good results. **R-E**

The L – R signal is also compressed by a complex noise-reduction technique known as dbx television noise reduction. (See the sidebar for more on dbx.) The level of the L – R signal is adjusted to produce 50 kHz of deviation.

At 78.67 kHz (five times the horizontal sweep rate) is the SAP subcarrier. It is limited to 10-kHz of deviation and is also dbx compressed.

Last, at 102.3 kHz (6.5 times the horizontal sweep), is the subcarrier for the professional channel. It is not compressed and is limited to about 3-kHz of deviation.

If the deviations of all sub-channels are added together, the total is 98 kHz (25 + 5 + 50 + 15 + 3). However, the total deviation is not allowed to exceed 73 kHz (50 + 15 + 3), because the sum of the deviations of the L + R and L – R signals is limited to 50 kHz. Although that total is greater than the deviation of a plain mono transmission, it fits into the guard band with room to spare.

If you're familiar with the stereo system used for FM radio transmissions, you'll notice that the stereo portion of the BTSC system is essentially the same as that used in FM radio, disregarding the SAP and professional channels. In fact, the main differences are the slightly different frequencies of the pilot and the L – R subcarriers. We can take advantage of those similarities by using an IC that is normally used to decode FM radio signals. Doing so simplifies our design and reduces costs considerably.

The circuit

A block diagram of the stereo-TV decoder is shown in Fig. 2. It shows the overall relationships between the separate sections of the circuit; Figures 3–6 show the details of each subsection.

Let's start with the decoder section (shown in Fig. 3). It centers around IC1, a

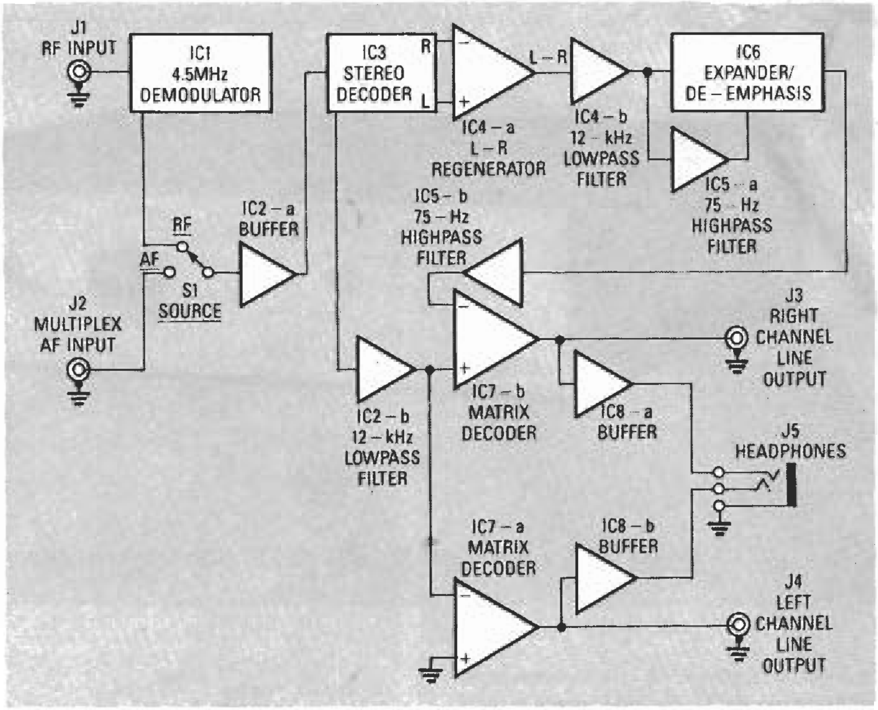


FIG. 2—EIGHT INEXPENSIVE IC'S are all it takes to provide a high-quality MTS decoder.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.

R1—120 ohms
R2, R7, R35, R37—10,000 ohms
R3, R23, R49, R53, R54—10,000 ohms, trimmer potentiometer
R4, R6, R11, R12, R42, R43, R44, R46, R48, R50, R51, R59, R60—100,000 ohms
R5—2200 ohms
R8—10 ohms
R9, R24, R31, R57, R58, R63—1000 ohms
R10, R16, R17, R28—3300 ohms
R13—330,000 ohms
R14, R15, R21, R62—4700 ohms
R18—12,000 ohms
R19—25,000 ohms, trimmer potentiometer
R20—4300 ohms
R22, R27—5100 ohms
R25—5,000 ohms, trimmer potentiometer
R26—1500 ohms
R29—30,000 ohms
R30—18,000 ohms
R32, R33, R39, R40—20,000 ohms
R34, R41, R55, R56—39,000 ohms
R36, R38—22,000 ohms
R45—68,000 ohms
R47—470,000 ohms
R52—100,000 ohms, dual-gang potentiometer
R61—330 ohms

Capacitors

C1, C4, C13, C32—0.01 µF, ceramic disk
C2, C9, C19—470 pF, ceramic disk
C3, C14—0.05 µF, ceramic disk
C5—5-60 pF, trimmer
C6—10 pF, ceramic disk
C7, C8, C10, C11, C27, C38, C47—1 µF, 50 volts, electrolytic
C12, C23, C25—0.0022 µF, ceramic disk
C15, C30, C34-C37—0.22 µF, ceramic disk
C16, C17—0.47 µF, ceramic disk
C18—0.0047 µF, ceramic disk
C20, C21—0.0015 µF, ceramic disk
C22, C24—0.0039 µF, ceramic disk
C26, C29—0.015 µF, ceramic disk
C28, C31, C39-C46—10 µF, 50 volts, electrolytic
C33, C50-C53—2.2 µF, 50 volts, electrolytic
C48—2200 µF, 50 volts, electrolytic
C49—470 µF, 50 volts, electrolytic

Semiconductors

IC1—MC1358 stereo demodulator
IC2, IC4, IC5, IC7, IC8—LM358 dual op-amp
IC3—LM1800 stereo decoder
IC6—NE570 compander
D1, D1—1N4002 rectifier diode
LED1, LED2—standard
Q1, Q3—2N3904 NPN transistor
Q2—2N3906 PNP transistor
Q4—2N2222 NPN transistor

Other components

F1—¼-amp, 250-volt fuse
J1–J4—RCA phono jack
J5—stereo headphone jack
L1—33 µH S1—SPDT toggle switch
S2—SPST toggle switch
T1—10.7 MHz IF transformer
T2—25-volt CT power transformer

Note: A drilled, etched, and plated PC board is available from Tod. T. Templin, 5329 N. Navajo Ave., Glendale, WI 53217 for $9.00.

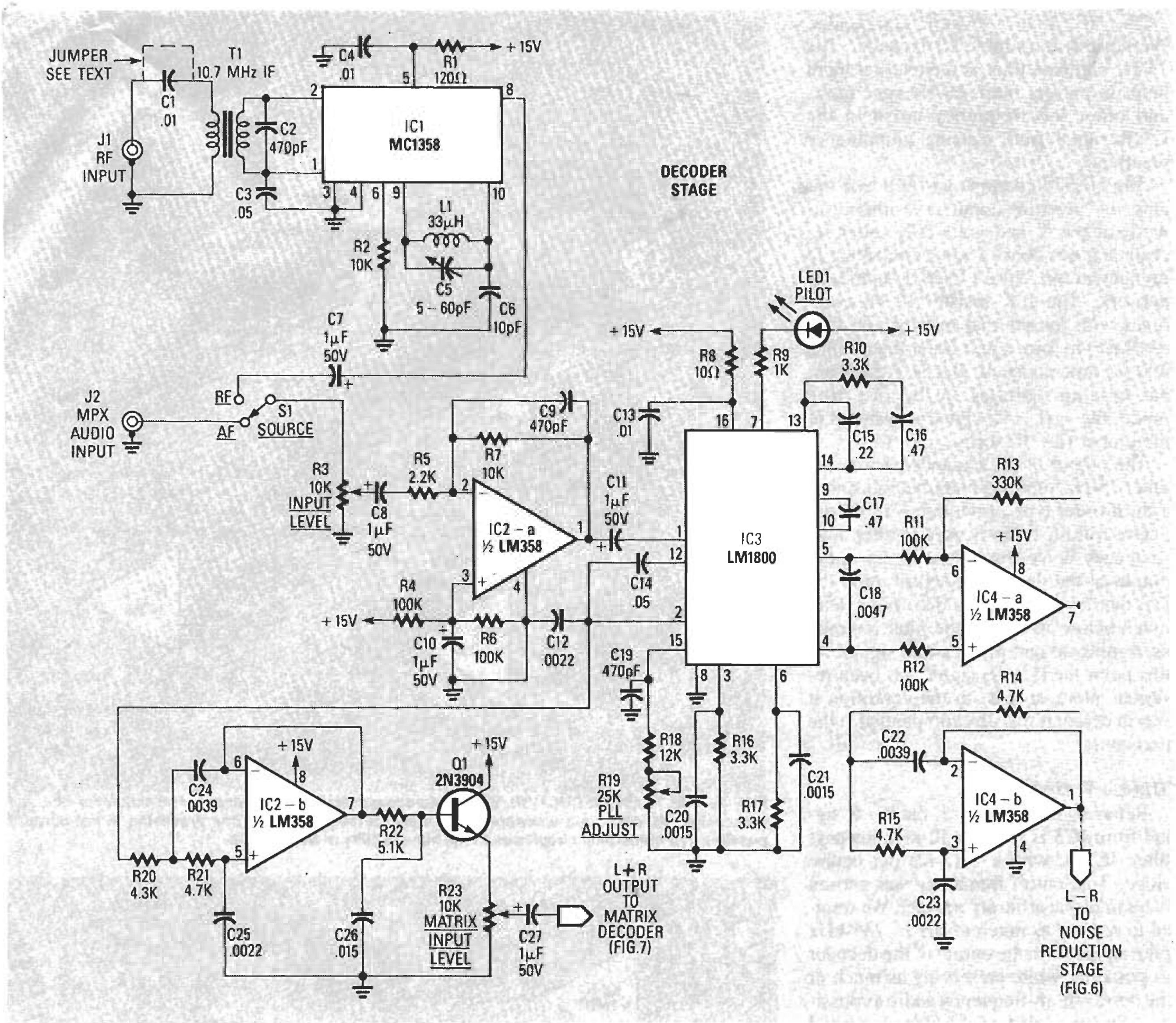


FIG. 3—THE DECODER STAGE converts the multiplexed audio signal into L + R and L − R signals.

standard 4.5-MHz audio demodulator that is used in many television receivers. The circuit is more or less what you find in the databook. The major exception is that the standard de-emphasis capacitor has been eliminated in order to ensure that the L − R signal is presented to the decoder. If present, the capacitor would roll off the high-frequency L − R signal.

The output of IC1 is routed to S1, which allows you to choose between the internally demodulated signal and an externally demodulated one. Buffer amplifier IC2-a then provides a low-impedance source for driving IC3, an LM1800 stereo demodulator. As with IC1, IC3 is used in a conventional manner. Our circuit differs from the cookbook circuit, however, in that the component values associated with the phase-locked loop have been altered so that the loop will lock on the 15.734-kHz MTS pilot rather than on the 19-kHz FM-radio pilot.

When IC3 is locked on a stereo signal, the outputs presented at pins 4 and 5 are the discrete left- and right-channel signals, respectively. In order to provide noise reduction to the L − R signal, we must re-combine the discrete outputs into sum and difference signals. Op-amp IC4-a is used to regenerate the L − R signal. It is wired as a difference amplifier, wherein the inputs are summed together (+L − R). Capacitor C18 bridges the left- and right-channel outputs of the demodulator. Although it decreases high-frequency separation slightly, it also reduces high-frequency distortion. After building the circuit, you may want to compare sound output with and without C18.

The L + R signal is taken from the LM1800 at pin 2, where it appears conveniently at the output of an internal buffer amplifier.

The raw L − R signal is applied to IC4-b, a 12-kHz lowpass filter. The L + R signal is also fed through a 12-kHz lowpass filter in order to keep the phase shift undergone by both signals equal. If only one were filtered, there would be a loss of high-frequency separation when the left and right channel signals were recovered.

Next, as shown in Fig. 4, the L − R signal is fed to Q2. That transistor has three functions. It allows us to add a level control to the L − R signal path; it provides a low source impedance for driving the following circuits; and it inverts the signal 180°. (Think of the signal at the collector of Q2 as −(L − R)). Inversion is necessary to compensate for the 180° inversion in the compander.

Next comes the expander stage; this is where we would use a dbx decoder if we could get one (see sidebar). At the collector of Q2 is a 75-μs de-emphasis network (R27 and C29) that functions just like the network associated with Q1 (in Fig. 3). Note that Q2 feeds both Q3 and IC5-a, a −12 db per octave highpass filter. The output of that filter drives the rectifier input of IC6, an NE570.

The NE570 is a versatile compander. We'll use it as a simple 2:1 expander. The 75-Hz highpass filter at the rectifier input helps to prevent hum, 60-Hz sync buzz, and other low-frequency noise in the L − R signal from causing pumping or breathing.

The NE570 contains an on-board op-amp; its inverting input is available directly at pin 5, and via a 20K series resistor at pin 6. That's a convenient place to implement the 390-µs fixed de-emphasis network. The 18K resistor (R30) combines with the internal resistor and C32 (0.01 µF) to form a first-order filter with a 390-µs time constant. Because the internal op-amp operates in the inverting mode, the −(L − R) signal is restored to the proper (L − R) form.

The output of the expander drives another 75-Hz highpass filter, but this one is a third-order type providing −18 db per octave rolloff. It too is used to keep low-frequency noise from showing up at the output of the decoder. Keep in mind the fact that television audio does not extend much below 50 Hz, so the filter removes no significant part of the audio signal. At this point the (L − R) signal has been restored, more or less, to the condition it was in before it was dbx companded at the transmitter.

The L + R signal

Referring back to Fig. 3, the L + R signal from IC3 is fed to a 12-kHz lowpass filter, IC2-b, with a −12 dB per octave slope. That cutoff frequency was chosen in a somewhat arbitrary manner. We wanted to remove as much of the 15.734-kHz pilot signal from the output of the decoder as possible, while preserving as much of the desired high-frequency audio as possible. So we settled on 12 kHz as a good compromise.

The output of the highpass filter is applied to a 75-µs de-emphasis network (R22 and C26). The L + R audio signal is now restored properly. We feed it through Q1, which is wired as an emitter follower to provide a high load impedance for the de-emphasis network and a low source impedance for level control R23. Next the L + R signal is fed to the matrix decoder, shown in Fig. 5.

Left and right recovery

Op-amps IC7-a and IC7-b are used to recover the individual channels. First, IC7-b is configured as unity-gain difference amplifier. The (L + R) is applied to its inverting input, and the (L − R) signal is applied to the non-inverting input. Therefore the output of IC7-b may be expressed as −(L + R) + (L − R) = −L + L − R − R = −2R. Similarly, IC7-a is configured as a mixing inverting amplifier. Here, however, both sum and difference signals are applied to the inverting input. So the output of IC7-a is −(L + R)

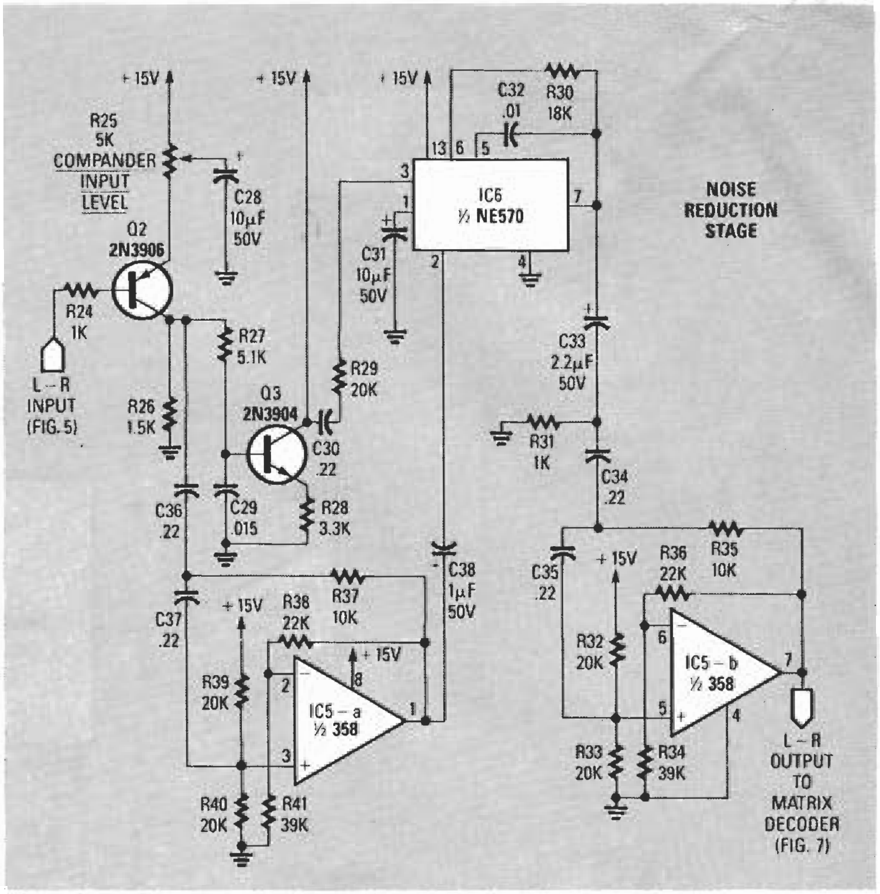


FIG. 4—THE NOISE-REDUCTION STAGE de-compands the L − R signal, and emulates dbx-style processing. As described elsewhere in this article (see box), true dbx procesing is not currently possible in a home-built circuit due to the inavailability of the dbx IC's.

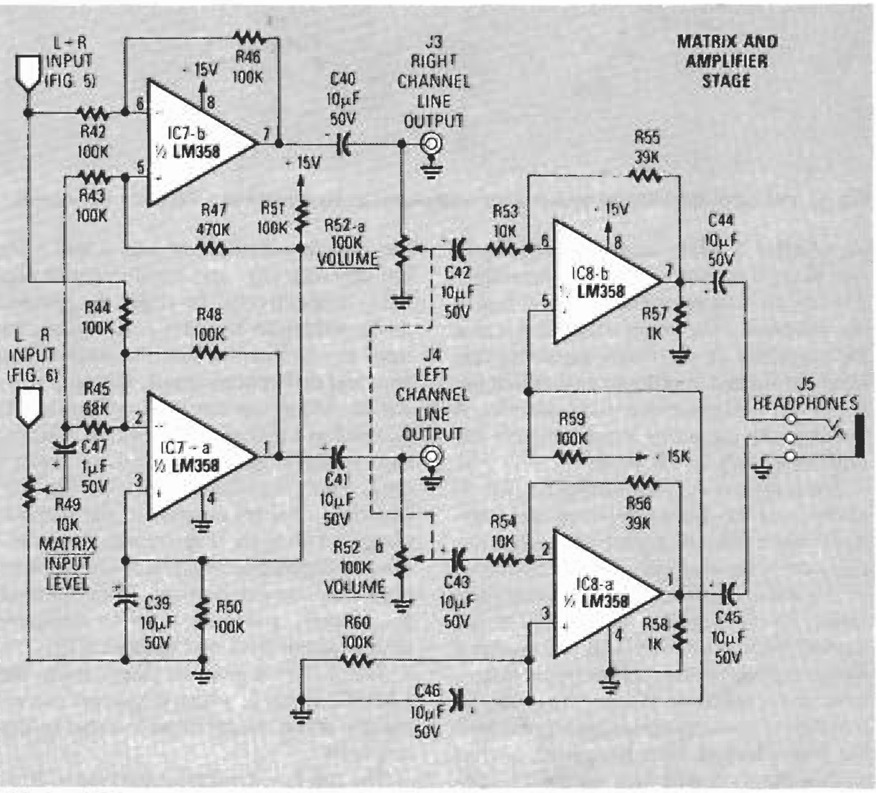


FIG. 5—THE MATRIX STAGE separates the L + R and L − R signals into the left- and right-channel components. Op-amp IC8 and associated components provide an optional headphone output. If you do not wish to drive a pair of headphones, or plan to use your amplifier's headphone jack for that purpose, all components to the right of jacks J3 and J4 can be deleted.

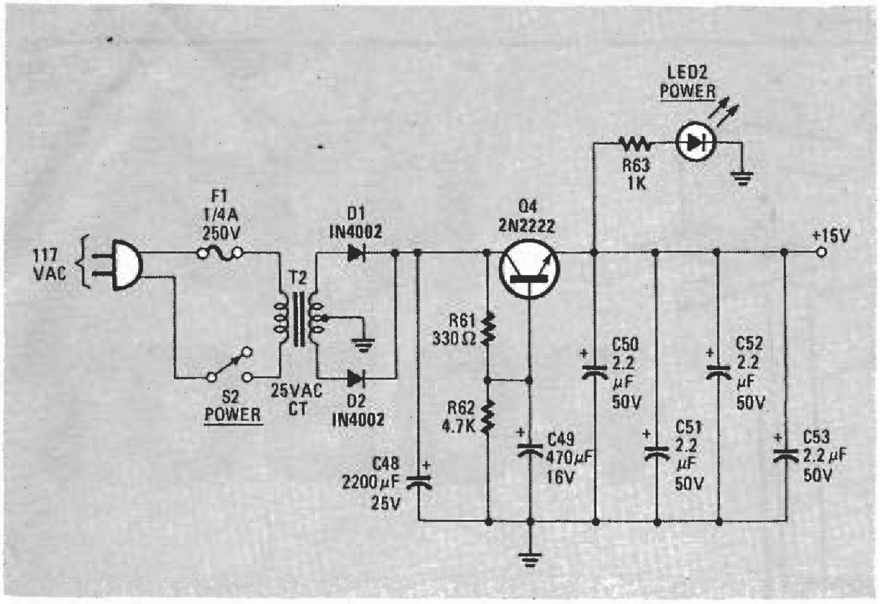


FIG. 6—THE UNREGUALTED POWER SUPPLY shown here provides extremely low ripple for the MTS decoder.

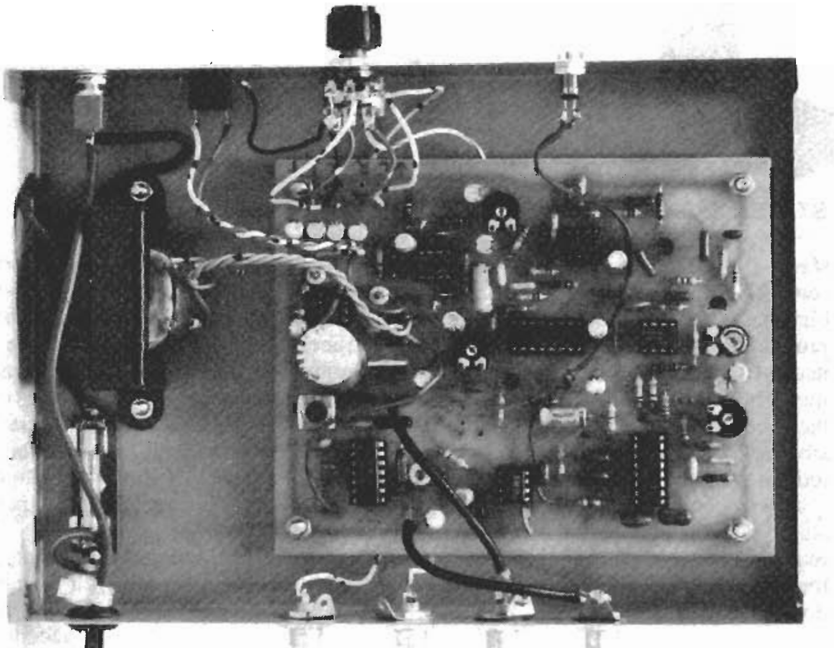
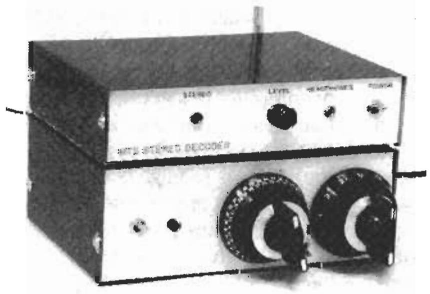


FIG. 7—THE COMPLETED STEREO DECODER BOARD. Next time, we'll show you how to build the circuit shown here.



AN OUTBOARD TUNER lets you use the circuit with a TV that lacks audio outputs. Next time, we'll see many other ways of using the circuit.

$-(L-R) = -L - R - L + R = -2L$. Because both channels have been inverted, the stereo relationship is preserved.

The two op-amps in IC8 provide an additional stage of amplification to drive a pair of stereo headphones. If you don't plan to use headphones, or if you are content to use only your stereo's headphone jack, all components to the right of line-output jacks J3 and J4 may be deleted.

The schematic of the decoder's power supply is shown in Fig. 6. It provides an unregulated 15-volt DC output. Transistor Q4 is used as a capacitance multiplier, to provide high ripple reduction. The four 2.2-μF capacitors (C50–C53) are distributed on the PC board (which we'll show next time) to keep the impedance of the power-supply rails low. That's important to minimize crosstalk between different sections of the unit.

As shown in Fig. 7, most of the circuitry we've described mounts on a single PC board. Unfortunately, we've run out of space for this month. When we continue we will show you how to build the circuit, as well as several methods of connecting the unit to a TV or VCR. At that time, the PC pattern will be provided. If you wish to get a head start, and are planning to purchase a pre-etched board, you can order one from the source provided in the Parts List. **R-E**

COMPENSATION

THE MARCH 1985 ISSUE OF **RADIO-ELECTRONICS** has a good description of the dbx system, but we'll summarize the salient features here. Keep in mind the fact that dbx operates only on the stereo difference signal (L − R).

- The signal is compressed at transmission by a fixed ratio of 2 to 1.
- The signal is pre-emphasized by a combination of 75-μs and 390 μs networks.
- The signal is spectrally companded by a variable ratio that depends on broadband frequency balance and signal level.

Of those three functions, spectral companding is the most difficult to compensate for. We include de-compression circuits and the proper de-emphasis networks, but we decided not to include spectral de-companding in our decoder, based on the following rationale.

Spectral companding's primary function is to mask high-frequency noise when the signal is composed primarily of low frequencies at relatively low levels. It does so by adding a variable amount of high-frequency pre-emphasis at the proper times. If the signal contains relatively high signal levels across the entire audio spectrum, little spectral companding is performed. Fortunately, in the real world of television broadcasting, high-level signals that extend across the entire audio spectrum are fairly common, so little dbx companding actually is performed.

All television stations use sophisticated audio processing devices to boost the audio level during quiet program material, and to limit the level during loud material (like commercials). Those devices generally divide the spectrum into three bands, and each band is independently monitored by the processor to ensure that the levels in each band remain relatively high.

The end result is that overall modulation remains high across the entire audio spectrum for most types of program material. Therefore, the dbx circuitry would do little spectral companding, so we made no attempt to compensate. **R-E**

BUILD THIS

STEREO TV Decoder

Are you still listening to TV in mono? Double your TV-listening pleasure with this stereo-TV decoder!

STEVE SOKOLOWSKI

STEREO SOUND—IT'S THE MOST EXCITING thing to happen to television since color! Now's the time for *you* to find out how exciting it can be. We explained what it is and how it works a year ago (in the February and March 1985 issues of **Radio-Electonics**). Now it's time to get your hands dirty. Our simple, one-IC circuit will double your viewing pleasure, yet it can be built for about the cost of a single pre-recorded videotape. But before we dive in to discuss circuit operation and construction, let's quickly review the basics of MTS (*M*ulti-channel *T*elevision *S*ound) transmission.

Stereo-TV signals

As with standard FM-broadcast signals, the stereo-TV audio signal has three components. As shown in Fig. 1, they are: the pilot signal, left + right (L + R) audio, and left − right (L − R) audio. In a conventional TV receiver the L + R signal, or the *main channel* is the only one that is detected—it's the monaural signal that you normally hear through your TV's speaker. Note that it is a frequency-modulated (FM) signal with a 75-µs pre-emphasis, and a bandwidth of about 15 kHz.

Just above the main channel is the *pilot* tone, which is used to alert the receiving circuitry that the L − R signal, or the *stereo-difference* subchannel is available for processing. The MTS pilot signal is 15.734 kHz—the standard TV horizontal-scanning frequency, f_H.

As you can see in Fig. 1, the L − R signal or *stereo subchannel* occupies the TV baseband frequency ranging from $2f_H$ to $3f_H$.

MTS allows for additional subchannels that can be used for a number of purposes. One possible audio-baseband configuration is shown in Fig. 1. That configuration incudes two additional subchannels: the SAP, or *S*econd *A*udio *P*rogram, channel (which can be used for bilingual broadcasts and other program-related material) and the *professional channel* (which can be used for communicating with remote news crews, and other non-program-related purposes.) Our stereo adapter cannot decode any of those additional subchannels.

Stereo TV is generated in a manner quite similar to the manner in which broadcast FM is generated. As shown in Fig. 2, separate left and right audio inputs are applied, after low-pass filtering, to the matrix that provides the stereo sum (L + R) and difference (L − R) signals. The sum, or monophonic, signal gets the 75-µs pre-emphasis; it is then clipped, filtered, and mixed with the difference signal. Rather than pre-emphasis, the L − R signal is processed by the *dbx* compressor/noise-reduction system. (See the article mentioned above for information on how that system works.)

Those audio signals are then mixed with the 15.734-kHz pilot signal, which, as we said above, is derived from the the horizontal sync. The resulting signal is filtered and then sent to the audio-modulation circuitry where it is modulated in the usual manner.

To receive stereo TV signals, all we really need is a circuit that will process that composite-audio signal in the converse manner. The basic idea is indicated in Fig. 3. The "TV detector" block separates the sum and difference channels, each of which is filtered (and expanded, if necessary). Then the L + R and L − R signals are applied to a matrix circuit that restores the original left and right channels. At that point they're ready for ampli-

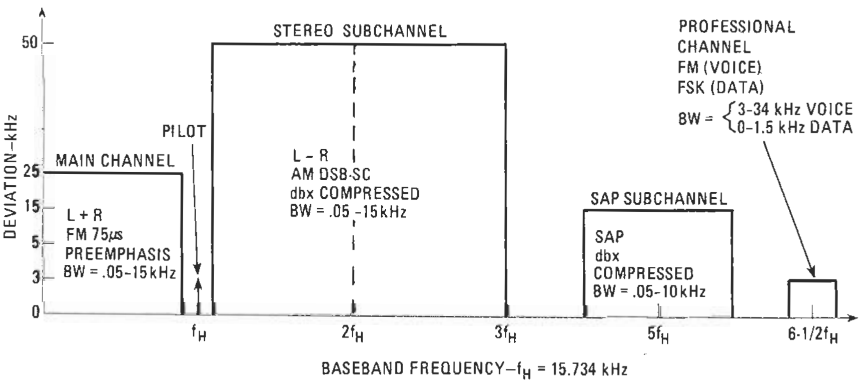


FIG. 1—THE MTS DISTRIBUTION OF SIGNALS provides for a monaural main channel, sub-channels for the stereo sub-carrier and a secondary audio program (SAP), and a professional channel for voice or computer (FSK) data.

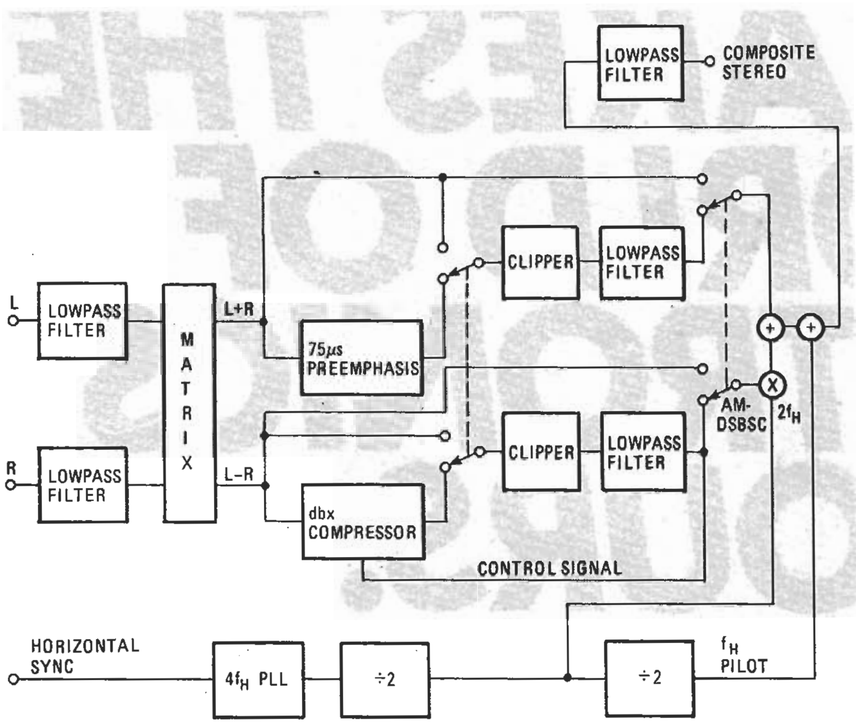


FIG. 2—MTS STEREO IS GENERATED in a manner similar to that of standard broadcast FM. MTS differs from broadcast FM in that it uses *dbx* noise-reduction, and the standard TV horizontal-scan frequency to generate the pilot tone.

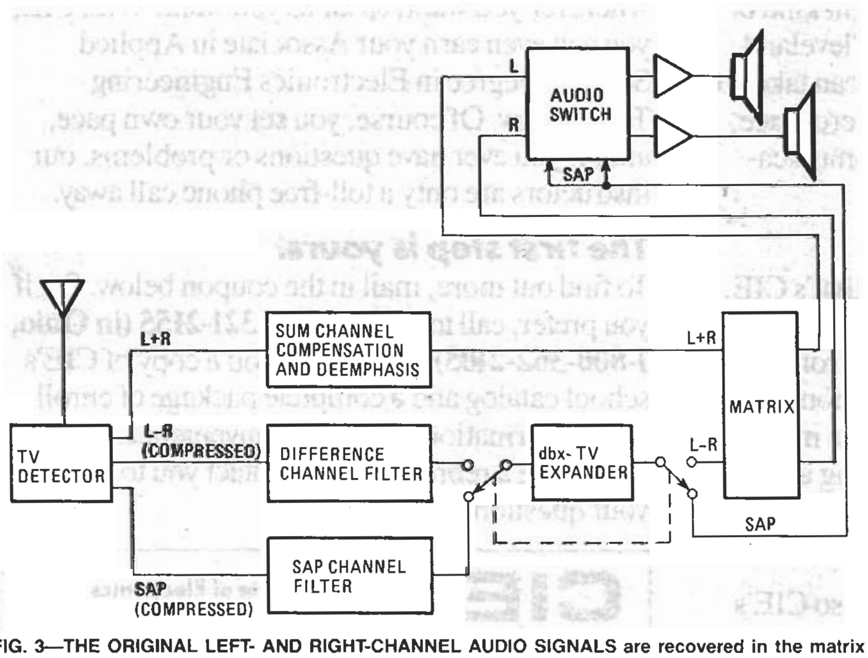


FIG. 3—THE ORIGINAL LEFT- AND RIGHT-CHANNEL AUDIO SIGNALS are recovered in the matrix decoder after filtering and de-emphasis of both L + R and L − R, and after expansion of the L − R signal by the *dbx* unit.

fication. (Note that the block diagram in Fig. 3 includes a SAP decoder, which our stereo adapter does not offer.)

If you're wondering how the original channels can be extracted from the sum and difference signals, examining the following equations should clear things up:

$$(L+R)+(L-R) = 2L$$

$$(L+R)-(L-R) = 2R$$

In other words, we can restore the left channel by adding the sum and difference signals, and we can restore the right channel by subtracting the difference signal from the sum signal. At that point all we have to do, in order to provide usable stereo-TV signals, is provide power amplification. So how can we extract the left- and right-channel signals?

Circuit description

The schematic of the stereo-TV decoder is shown in Fig. 4. Assume for now that it is connected to a proper source of composite audio. We'll show you how to do that in a minute.

The composite input signal is preamplified by transistor Q1 and is then coupled to the high-pass filter composed of C3, C4, R6, and R7. The filtered audio is then passed to IC1, an MC1310P "Coilless Stereo Demodulator." That IC is normally used to demodulate broadcast-band FM signals, but by changing the frequency of its on-board VCO (*V*oltage *C*ontrolled *O*scillator) slightly (from 19 kHz to 15.734 kHz), we can use that IC to detect stereo-TV signals.

A block diagram of the MC1310P is shown in Fig. 5. Notice that the components connected to pin 14 control the VCO's frequency, hence the pilot-detect and carrier frequencies. For use in an FM receiver, the VCO would run at four times the 19-kHz pilot frequency (76 kHz), but for our application, it will run at four times the 15.734-kHz pilot frequency of stereo TV, or 62.936 kHz.

The MC1310P divides that master VCO signal by two in order to supply the 31.468 kHz carrier that is used to detect the L − R audio signal. The L − R signal undergoes normal FM detection, and at that point we've got two audio signals: L + R and L − R. The *decoder* block in the IC performs the addition and subtraction to produce the separate left and right signals.

Referring back to the schematic in Fig. 4, R10 and C10 form a de-emphasis network that compensates for the 75-μs preemphasis that the left channel underwent; R12 and C11 perform the same function for the right channel. Now we've completely restored the original audio signal—almost.

You'll recall, in Fig. 3, the *dbx* expander circuit. We have provided no *dbx* expansion because *dbx* IC's haven't been released for general distribution. (They're available only to licensed OEM's.) So to provide some noise reduction (which will be necessary if you live in a less-than-ideal reception area), what we can do is connect our adapter to a non-*dbx* noise-reduction system. Alternatively, we can connect our adapter to a stereo system with a built-in noise reduction system. *(Another possibility would be to connect the stereo-TV decoder to the experimental compander discussed in the November, 1985 issue of **Radio-Electronics**—Editor.)*

None of those solutions is perfect, so the stereo TV you'll receive is less than ideal. However, we'll get no stereo TV at all if we don't start building an adapter—so let's do it now!

Construction

Since we're not dealing with very high frequencies, the adapter can be built in just about any convenient manner. A PC board will simplify construction, though, so we've included a foil pattern in "PC

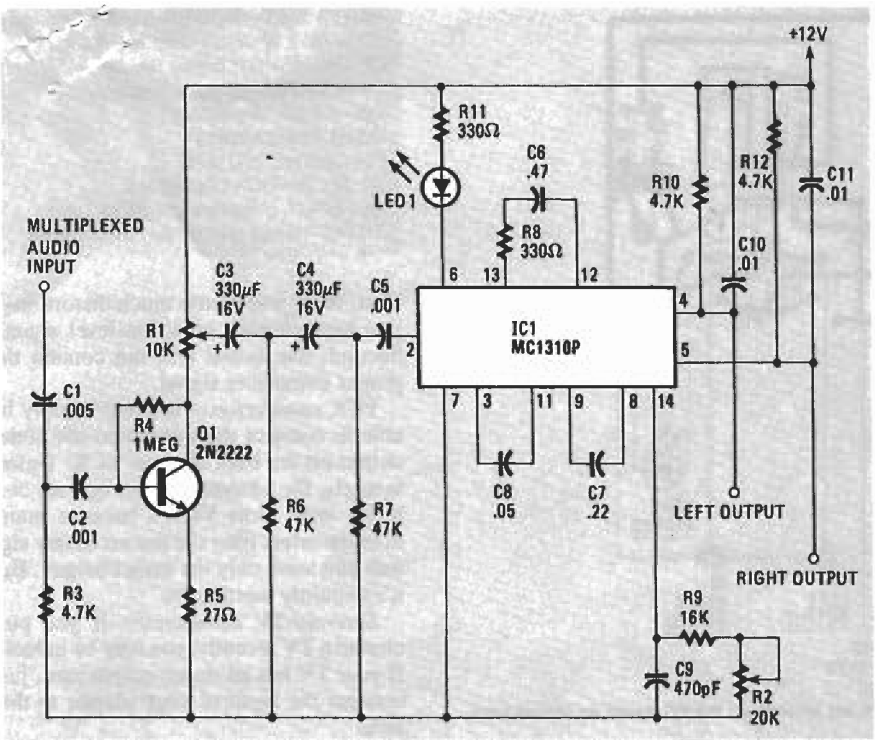


FIG. 4—THE CIRCUIT OF OUR MTS ADAPTER is quite simple, as shown here. The transistor provides a little pre-amplification for the IC (an MC1310P), which decodes the left and right audio channels.

PARTS LIST—MAIN BOARD

All resistors ¼-watt, 5% unless otherwise noted.

R1—10,000 ohms, audio taper, PC-mount, trimmer potentiometer
R2—20,000 ohms, linear taper, PC-mount, trimmer potentiometer
R3, R10, R12—4,700 ohms
R4—1 megohm
R5—27 ohms
R6, R7—47,000 ohms
R8, R11—330 ohms
R9—16,000 ohms

Capacitors

C1—0.005 μF, ceramic disc
C2, C5—0.001 μF, ceramic disc
C3, C4—330 μF, 16 volts, electrolytic
C6—0.47 μF, ceramic disc
C7—0.22 μF, ceramic disc
C8—0.05 μF, ceramic disc
C9—470 pF, ceramic disc
C10, C11—0.01 μF, ceramic disc

Semiconductors

IC1—MC1310P or LM1310 or XR1310 "Inductor-less" FM stereo demodulator
Q1—2N2222
LED1—Standard red LED

Note: A kit containing the main PC board and all parts that mount on it is available for $30.00 plus $1.50 for shipping and handling. Order from Del-Phone Industries, Inc., P. O. Box 150, Elmont, NY 11003. New York residents must add applicable sales tax.

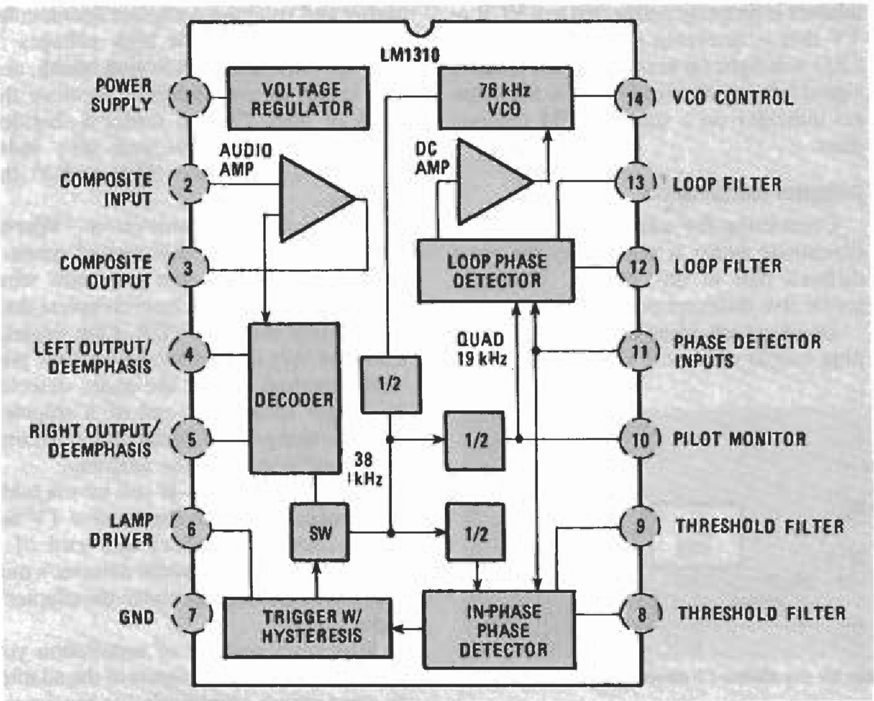


FIG. 5—THE MC1310P WAS DESIGNED FOR BROADCAST-FM decoding, but the stereo-TV pilot tone and carrier can be generated by altering the IC's VCO frequency from its nominal 76-khz value.

Service." You can also buy a PC board and a kit of parts; see the Parts List for more information.

Use the parts-placement diagram in Fig. 6 and the photo in Fig. 7 as a guide for mounting all components. Use a socket for IC1. Be sure to orient Q1 correctly, and don't apply too much heat to the transistor.

In Fig. 7 you'll notice a small board to the right of the main PC board. That's a 7812 regulator circuit that supplies 12-volts DC for the circuit. The schematic of that circuit is shown in Fig. 8. The foil pattern for the power-supply board is also shown in "PC Service," and the parts-placement diagram is shown in Fig. 9. For our prototype, we used a small wall-mount transformer to supply AC to the power supply.

When you've got the PC boards assembled, check them over carefully for solder bridges between adjacent pads and traces on the PC board. And make sure that all polarized components—IC1, Q1, LED1, the electrolytic capacitors—are installed correctly. When everything looks OK, it's time to align and install the adapter.

Alignment

You'll need an audio oscillator and a frequency counter to align the adapter. Connect the frequency counter to the oscillator and adjust the oscillator for a frequency of exactly 15.734 kHz at about ½-volt p-p. Then connect the output of the oscillator to the input of the adapter, and apply power. Adjust trimmer potentiometer R1 to its center position, then adjust trimmer potentiometer R2 until LED1 illuminates. If you have trouble getting the LED to light up, adjust R1 to allow more signal to get through to IC1.

If you don't have an audio oscillator and a frequency counter, you can align the adapter by connecting your adapter to a source of composite TV audio, as described below, and then tuning in a local station that you know is broadcasting in stereo. With the adapter connected to your stereo system, and R1 set in the center of its range, slowly adjust R2. Watch for the LED to light up, and then adjust R1 and R2 for best received audio.

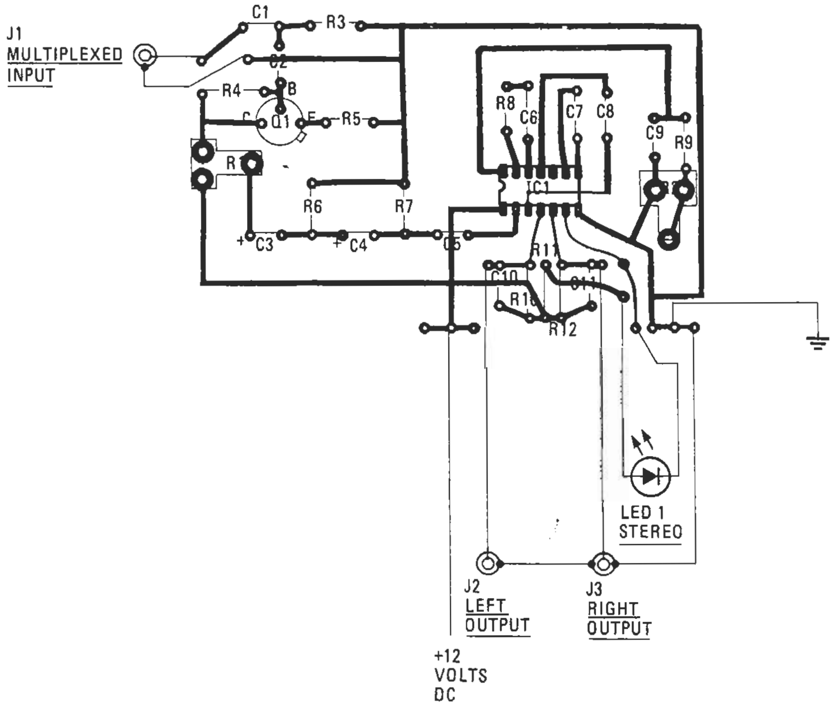


FIG. 6—THE STEREO-TV DECODER'S COMPONENTS are located on the PC board as shown here.

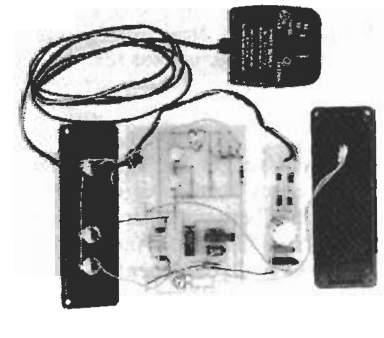


FIG. 7—YOUR STEREO-TV DECODER'S PC BOARD should look like this after all components are mounted.

That completes alignment! What we did was simulate the 15.734-kHz pilot signal with the audio oscillator. When the adapter is properly connected to a VCR or TV that is receiving a stereo signal, the LED will light up to indicate that a stereo signal is being received—just as the STEREO indicator on a standard FM receiver does.

Adapter installation

Connecting the adapter to a source of composite audio is potentially the most difficult part of this project. We'll describe five different possibilities.

Don't get any ideas about using the earplug output of your TV, VCR, or radio. First, there will be too much distortion—you have to pick up a low-level signal. Second, the output will not contain the proper composite signal.

VCR connection—You *may* simply be able to connect the adapter to the audio output on the back of your VCR. Unfortunately, the adapter will not operate correctly with most VCR's because many manufacturers filter out the necessary signals and leave only the main channel. But it's certainly worth a try.

External-TV connection—If you purchased a TV recently, you may be in luck. If your TV has an stereo output jack, just connect the input of your adapter to that jack.

Internal-TV connection—**Warning**—Don't attempt this sort of connection unless you are sure you know what you are doing and you have complete documentation for your TV. The high voltages in your TV are hazardous to your health, and the health of your adapter! Remove the back of your TV and solder a shielded cable to the output of your set's audio detector. Connect the other end to the adapter.

Internal-VCR connection—**Warning**—Don't attempt this sort of connection unless you are sure you know what you are doing and you have complete documentation for your VCR. One mistake could be very expensive! As with the previous method, locate the audio detector IC. Then solder one end of a shielded cable to that point. Connect the other end to the audio input of the adapter.

Radio connection—If you have a table or portable radio that can receive TV audio, *carefully* connect one end of a shielded cable to the audio detector's output. Connect the other end to the adapter's input.

Whichever method of installation you choose, connect the outputs of the adapter to your stereo amplifier's (or receiver's) auxilliary inputs and fine-tune the alignment.

Conclusions

Stereo TV is still new, so even though many programs are now recorded in stereo (such as *Johnny Carson* and *Miami Vice*), not all stations are equipped to broadcast stereo audio. For a partial listing, check the back issues of **Radio-Electronics** mentioned above, or call your local TV stations. **R-E**

PARTS LIST—POWER-SUPPLY
IC1—7812 12-volt, 1-amp regulator
D1–D4—1N4001 power rectifier
C1—2200 µF, 25 volts, electrolytic
C2—0.1 µF, monolithic
Other components
F1—¼-amp, 250 volts
J1, J2, J3—RCA phono jack
S1—SPST, miniature toggle
T1—12–18-volt wall-mount transformer

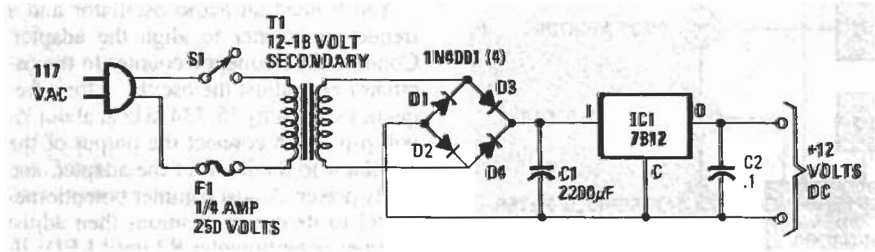


FIG. 8—THIS POWER SUPPLY provides plenty of power for the stereo-TV decoder.

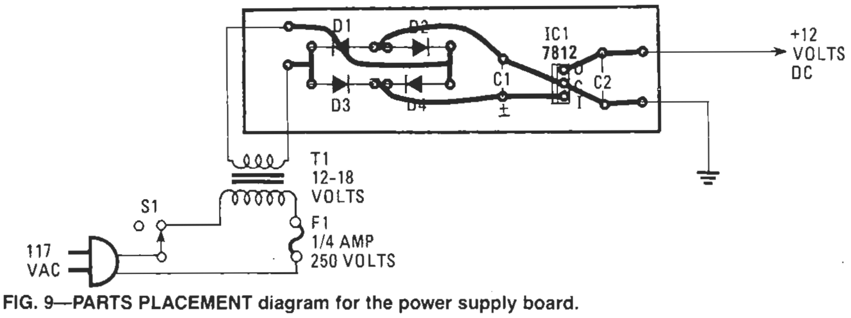
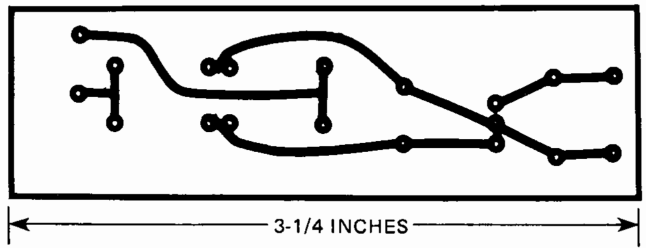
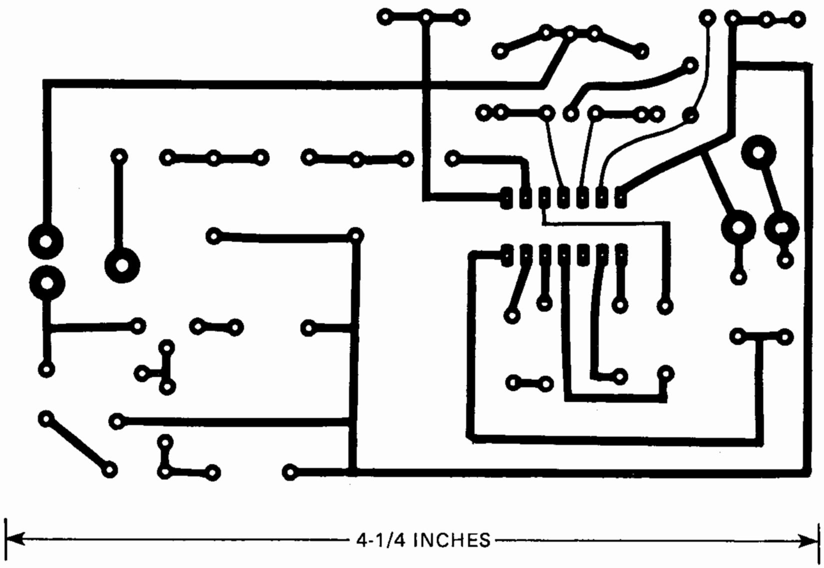


FIG. 9—PARTS PLACEMENT diagram for the power supply board.



USE THIS BOARD for the power supply required by our stereo-TV decoder.



HEAR YOUR FAVORITE TV SHOWS in stereo with our stereo-TV decoder. The main board is shown here; the story begins on page 51.

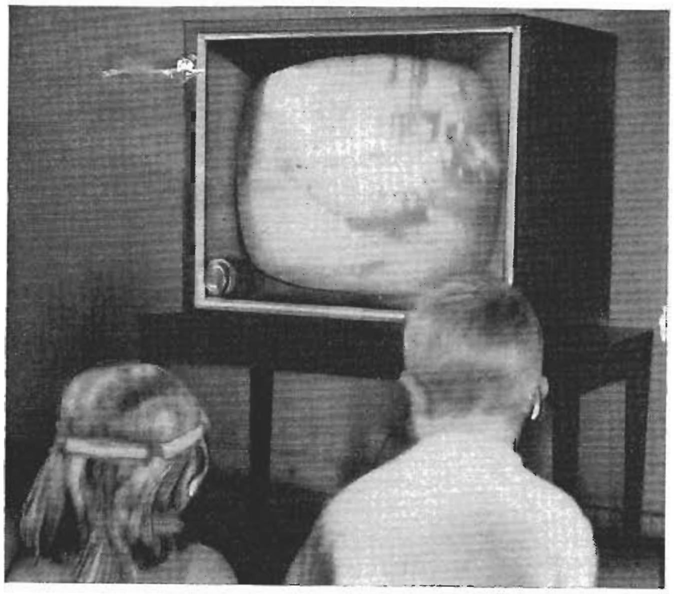
OOOOPS!

I have received some letters from **Radio-Electronics** readers in regard to my article on the TV Stereo Adapter that appeared in the March 1986 issue. Those letters complained that the Adapter does not operate.

Reviewing the schematic presented, I understood the reason for the complaints: there is an omission in the schematic. Pin 1 of

the MC1310 IC should be connected to +12 volts. Without that connection, the Adapter certainly will not operate.
STEVE SOKOLOWSKI

By SAM HAMILTON



silent TV listening

Listen to TV without disturbing others or being tied to the set by headphone leads

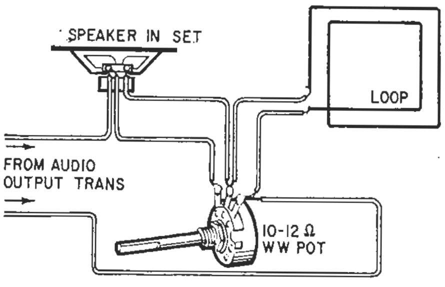


Fig. 1—Transmitter hookup at set.

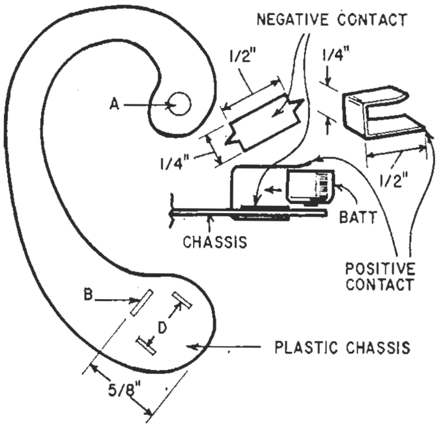


Fig. 2—Chassis and battery contacts for the receiver.

HAVE YOU EVER WANTED TO WATCH A late TV show, but had to call it off because other members of the family had retired? Does TV disturb those who wish to read or study? Is there someone in your home with a hearing defect who must turn up the volume, causing discomfort to others?

These are common problems in many homes but, if the TV sound could be confined to only those who wish to hear it, there would be no problem at all.

One easy solution is headphones. But this ties the listener to the set and leaves connecting wires all over the place.

The best solution is to use electromagnetic induction to "transmit" the audio portion of the program and little audio receivers and individual headsets to receive the sound. It's simple to set up—all you do is connect a loop of wire into the speaker circuit of your TV (it can also be used for radio and record players). This loop becomes a transmitting antenna that radiates the sound from your TV. Loop size depends upon the area you wish to cover, but make it as large as possible. It may be installed in the attic or on the basement ceiling. If this is not possible, mount it on the wall or under the rug. For a wall-mounted loop, I use 10 turns of ordinary hookup wire around the limits of the wall. You can even wind a loop right on the back of the TV. For this you'll need at least 20 turns. But remember, the larger the loop, the greater the listening area and the louder the received sound. Also, a small loop requires more power than a large one for the same amount of coverage.

Fig. 1 shows how to connect the loop to the TV. Mount the potentiometer on the side of the cabinet or right on the back panel. If you use the back panel, make sure the leads from the control are long enough to allow for removing the back for repairs.

You can use a switch in place of the pot if you wish. I prefer the pot as either sound or silent listening can be given preference in volume.

The receiver is a small transistor amplifier. It is very similar to a hearing aid, the only difference being the receiver has a pickup coil where a hearing aid would have a microphone.

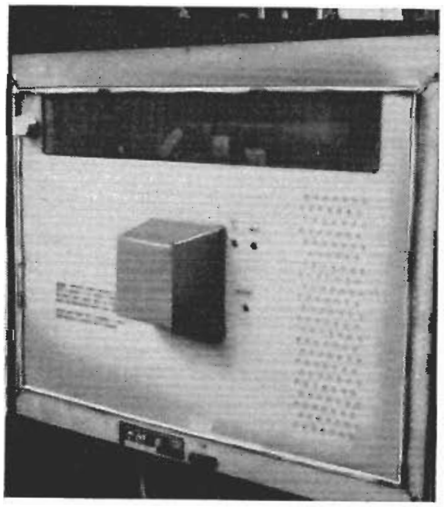
It is possible to get somewhat limited reception without any amplifier at all with only an earphone. This can be further improved by connecting the earphone to a small loop 7 inches in diameter with 20 turns of No. 18 wire. We use this system when we haven't enough amplifiers to go around. To get away from the dangling cord and get more freedom of movement, the coil is worn like a halo.

Building the receiver

Designed to hang on the ear, the receiver is completely self-contained. Its chassis is a piece of soft pliable plastic. I cut mine from a squeeze bottle and suggest that you make a cardboard template to get the shape and size right before cutting the plastic. If you prefer a ready-made chassis with an earphone already attached, try the Lafayette AR-50 earphone. You may have to crowd the components a little, but they should all fit nicely.

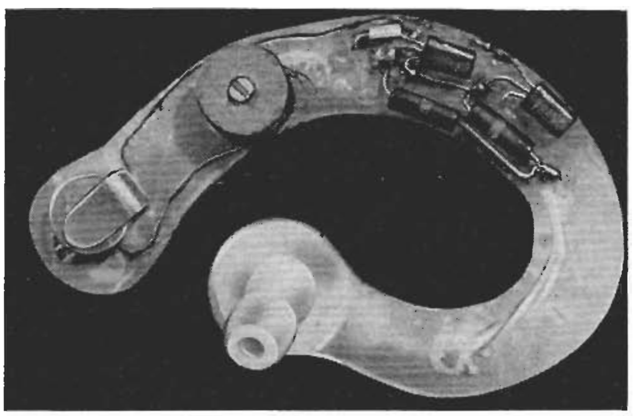
The plastic chassis and battery contacts are shown in Fig. 2. Bend the lugs on the negative battery contact at right angles and insert them in slits D in the base. Then bend them over to hold the contact in place. Insert the lower end of the positive contact through slit B in the base.

Pass the lip of the earphone, to which the eartip mold is attached, through hole A in the plastic base, then

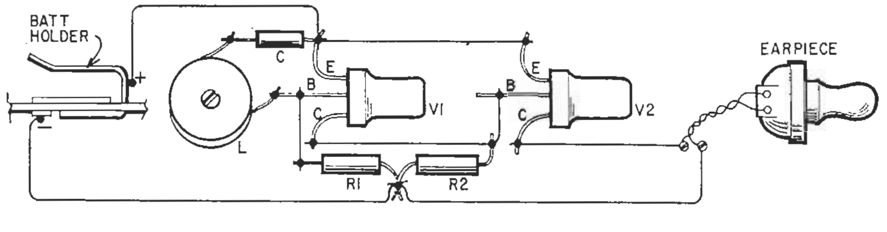


You can wind the transmitting loop behind the TV.

The whole receiver fits behind your ear.



R1—22,000 ohms, 1/4 watt
R2—1,000 ohms, 1/4 watt
C—Miniature electrolytic, 1 to 6 μf (not critical) 3 volts
L—pickup coil (see text)
V1, V2—CK784 or other pnp audio transistor
1.4-volt mercury battery (Mallory RM675, RM630 or equivalent)
High-impedance earpiece (Lafayette AR-50 or MS-260)



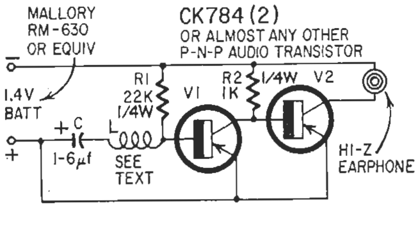


Fig. 3—Circuit (left) and component arrangement (above) for the receiver.

snap the eartip mold back in place. If the plastic chassis is too thick for the mold to snap onto the earphone, enlarge hole A to pass the mold.

The receiver circuit is in Fig. 3. Those who prefer a ready-made amplifier should try Lafayette's PK-522. Simply use a pickup coil rather than a mike at the amplifier input. This amplifier is a bit bulky and will not fit behind your ear. Carry it in your shirt pocket and run a connecting cable to the earpiece.

The pickup coil I used is a spool type coil 1/4 inch deep, 1/2 inch in diameter, and wound full of No. 40 enameled wire on the spool winder of a sewing machine.

Another possible pickup coil is a small high-impedance iron-core unit. Its length should be greater than its diameter. I've used one other coil successfully. It was wound around four 3/16 x 1 1/4-inch strips of transformer lamination. Use No. 40 enameled wire and wind enough for about 500 ohms dc resistance.

Coupling capacitor C is a subminiature electrolytic—any value between 1 and 6 μf will work. Almost any p-n-p small-signal audio transistors can be used for V1 and V2. The earphone is a high-impedance magnetic unit. The two-transistor receiver draws 1.5 ma. Removing the battery turns it off.

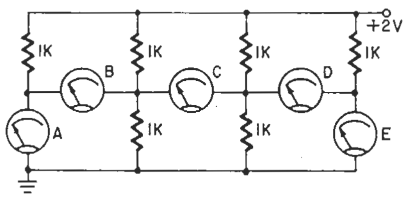
Cement all components to the plastic chassis with clear nail polish. Solder all leads to anchor points made by looping short lengths of wire over the component leads and through small holes in the chassis. Once the unit is completed and you are sure it works, coat the whole assembly with a liberal layer of clear nail polish, but be sure you don't get any on the battery terminals.

Of the many advantages of silent listening, the important one is you have one ear free for other sounds around the house which you otherwise would not hear. END

Three puzzlers for the student, theoretician and practical man. They may look simple, but double-check your answers before you say you've solved them. If you've got an interesting or unusual answer send it to us. We are especially interested in service stinkers or engineering stumpers on actual electronic equipment. We are getting so many letters we can't answer individual ones, but we'll print the more interesting solutions (the ones the original authors never thought of). We will pay $10 and up for each one accepted. Write EQ Editor, Radio-Electronics, 154 West 14th St., New York, N.Y.

Answers for this month's puzzlers are on page 76.

Voltmeter Puzzle



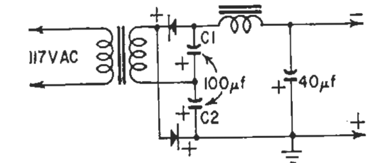
Voltmeters B, C and D show zero volts. What is the voltage reading on voltmeter A and voltmeter E?—*Kendall Collins*

How Many Diodes?

What is the lowest number of diodes required to obtain full-wave rectification?—*Richard L. Koelker*

Doubling in Capacitors

The circuit below is a full-wave



doubler bias supply for a push-pull class-AB1 amplifier. If capacitor C1 were to open, what would happen?—*Edward R. Beach.*

That Four-Bulb Puzzler

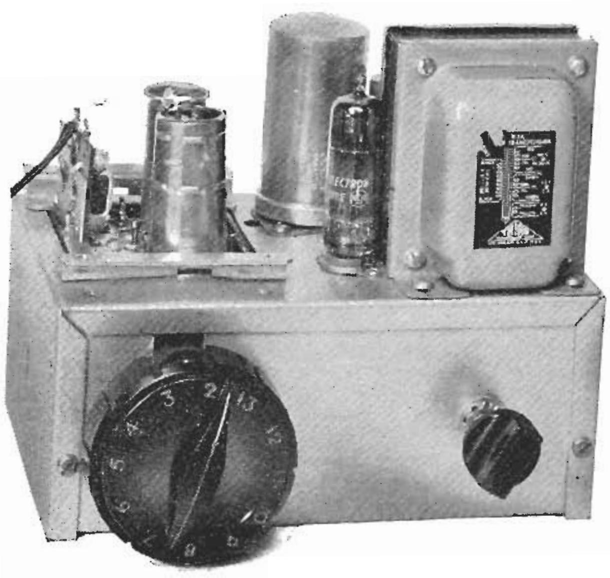
A number of our readers have called our attention to the fact that 6-volt (or fractionally higher rating) Zener diodes would give better results in the circuit (March, page 59) than thermistors, since they would not use any power until the bulb failed, and that, when it failed, the voltage drop across the Zener diode would be a closer approximation to that of the bulb than would be the case with a thermistor.

Correction

A number of readers caught the error in the answer to the question "How Much Voltage" in this column of the April issue. The error was in equation 4. It should have read

$$2/3(0.3E_{in}) + 0.1E_{in} = 10$$
$$0.2E_{in} + 0.1E_{in} = 10$$
$$0.3E_{in} = 10$$
$$E_{in} = 33.33 \text{ volts}$$

Our thanks to all the readers who spotted the error. END



The converter is a neat little package about twice the size of a TV tuner.

Simple converter adds TV sound to your FM tuner

high-fidelity TV sound

By M. HARVEY GERNSBACK
EDITOR

Have you ever tried piping TV sound through your hi-fi system when a particularly good program was on? Taking the sound from the ratio detector of the typical intercarrier TV leaves a lot to be desired. Sync buzz, distortion and background noise show up like a sore thumb when fed through a good audio system.

If you own a good FM broadcast tuner, you can build a converter to provide high-fidelity, noise-free reception from the sound channels of your local TV stations. If the FM receiver is sensitive and you have a reasonably good TV antenna, it will provide good sound reception from TV stations up to 75 miles away.

The unit converts the TV sound carrier of any TV channel to 88 mc. This is within the tuning range of any FM receiver or tuner (tuning range 88–108 mc). The FM tuner picks up the 88-mc output of the converter and handles it as though it were an FM station operating on 88 mc.

Unlike previous converters this one does not require two local oscillators to convert the TV sound carrier to 88 mc. Only one is necessary.

Suppose your local TV station is channel 4. The sound carrier of channel 4 is at 71.75 mc. We use an ordinary 44-mc i.f. TV front end at the input of our converter to change this to a 41.25-mc sound i.f. But we need 88 mc. Suppose we added a doubler–amplifier to the TV front-end output. This would produce a new i.f. at two times 41.25, or 82.5 mc. That's better, but it's still not 88 mc.

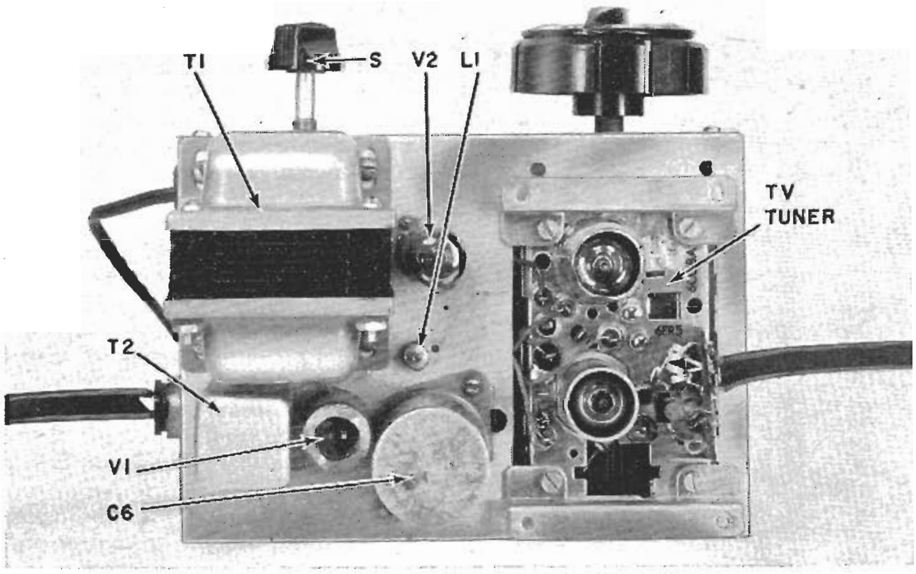
But we can change the i.f. output of the TV front end by changing the local oscillator frequency (adjusting the oscillator slugs or trimmers) and retuning the i.f. output slug to match. Suppose we raise the oscillator frequency by 2.75 mc. This will raise the sound i.f. output by the same amount to 44 mc. Now if we double 44 mc we should have the 88-mc i.f. we want! This sounds fine—but will it work? The answer is yes! The tuning range of the slugs on most TV front ends permit a shift of 4 or 5 mc, and a simple one-tube doubler–amplifier (an overbiased i.f. amplifier with its grid tuned to 44 mc and its plate to 88 mc) is all we need to complete the job.

Why not use a 21-mc front end?

"Fine," you say. "I've got an old 21-mc TV front end stashed away in the corner. I'll set its output to *22 mc and double twice* (quadruple to you) to get my 88-mc output!" I've got sad news for you: The output on your FM tuner will probably sound very distorted! Here's why.

An FM signal swings back and forth across its nominal carrier frequency, the amount of swing corresponding to strength of modulation. FCC rules for FM *broadcast* stations specify a maximum swing of ±75 kc at 100% modulation (a total band of 150 kc) and the FCC assigns station channels 200 kc apart, providing a 50-kc guard band between channels. FM receiver designers take this into account and provide a selectivity characteristic which will pass a bandwidth of from 150 to 200 kc so that the modulation peaks won't be chopped off.

Unlike FM broadcast stations, the FM sound channel of a TV station is allowed to swing only ±25 kc (50 kc total bandwidth) at 100% modulation



Top chassis view showing parts layout.

to conserve channel space.

Now let's go back to our i.f. amplifier–frequency-doubler stage. When we doubled the 44-mc TV sound carrier, *we also doubled its frequency swing.* The resulting 88-mc signal has a frequency swing of ±50 kc around 88 mc. (Remember that TV sound transmissions swing only ±25 kc.) This swing is still less than the ±75 kc of FM *broadcast* stations so the FM receiver will handle it with no trouble. But suppose we used a 22-mc i.f. and quadrupled it. *Our frequency swing would also be quadrupled* so we would have an 88-mc signal swinging ±100 kc. This is 25% greater swing than FM broadcast stations; the selectivity of most FM receivers would be too great to handle it. Serious distortion of a clipping type would occur every time the signal swung to its maximum during modulation peaks. Another objection to the 21-mc front end: Quadrupling would require a two-stage doubler, adding another tube and i.f. transformer and complicating construction.

The final circuit

The finished converter is a four-tube job: two tubes in the TV front end —a 6ER5 rf amplifier, and a 6CG8-A oscillator-mixer—and a 6EW6 44- to 88-mc doubler–amplifier, and a 6X4 rectifier.

The front end is a Standard-Kollsman GG-4290-A guided-grid replacement type 40-mc TV front end. We used it because of its compactness, general availability and good performance. An earlier converter using a surplus RCA KRK-29 cascode tuner gave equally good performance. However, the RCA tuner is much bulkier and readjusting the oscillator slugs is trickier. Also, it may no longer be generally available. *Any* 40-mc TV front end should work out satisfactorily. (If you are in a uhf TV area, uhf strips are available for the GG-4290A front end.)

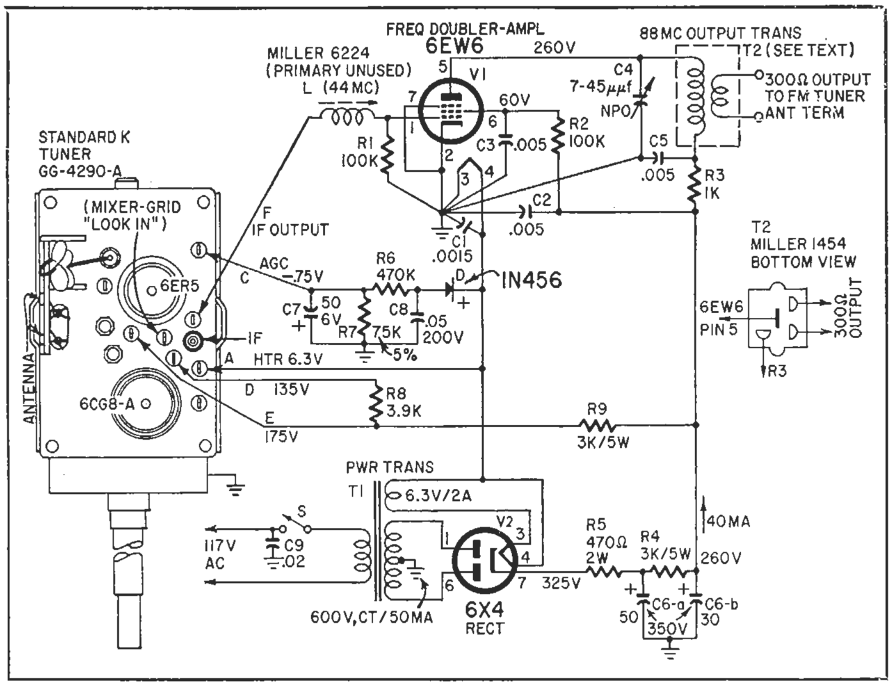
We show two schematics—one for use with the Standard tuner (Fig. 1), the other for the earlier RCA job (Fig. 2). The only differences are in the resistors in the B-supply and in the method of coupling the TV front-end outputs to the 6EW6 grid.

Construction

A one stage amplifier–doubler does not present any real construction problems. But the high frequencies require careful parts placement and one-point grounding to the chassis. Note that R1, C1, C2, C3, C4 and C5 ground to a common point at the socket of V1. This is important and must be done.

The Standard tuner is mounted in a 3½ x 2½-inch cutout in the 3 x 5 x 7-inch aluminum Minibox. It is clamped to the Minibox with the mounting brackets supplied with the tuner. The original converter had the KRK-29 tuner mounted outside the Minibox and secured to its side by a metal bracket. The KRK-29 tuner is larger than the Standard tuner.

In wiring output transformer T2, note that, although it is a standard FM



R1, R2—100,000 ohms
R3—1,000 ohms
R4, R9—3,000 ohms, 5 watts
R5—470 ohms, 2 watts
R6—470,000 ohms
R7—75,000 ohms, 5%
R8—3,900 ohms
All resistors ½-watt 10% unless noted
C1—.0015 μf, ceramic disc
C2, C3, C5—.005 μf, ceramic disc
C4—7-45 μμf, NPO, ceramic trimmer
C6—50-30 μf, 350 volts, electrolytic
C7—50 μf, 6 volts, electrolytic
C8—.05 μf, 200 volts, paper
C9—.02 μf, disc ceramic
D—1N456
L—44-mc coil (secondary of Miller No. 6224 transformer, primary not used)
S—spst toggle
T1—power transformer: primary, 117 volts; secondary, 650 volts ct, 50 ma; 6.3 volts, 2 amps (see text for data on optional transformer or use Triad R-7A or equivalent)
T2—88-mc transformer (Miller No. 1454 or 1447, see text)
V1—6EW6
V2—6X4
Tuner—Standard Kollsman GG-4290-A or RCA KRK-29
Chassis, 3 x 5 x 7 inches
Miscellaneous hardware

Fig. 1—Converter circuit using Standard Kollsman GG-4290-A TV tuner.

antenna coil, we are using it with reversed connections. The normal secondary is used as the primary, tuned by ceramic trimmer C4. The 300-ohm primary is used as our secondary to couple the converter to the FM receiver antenna terminals.

The type 1454 transformer that we used was dropped from the 1962 Miller catalog but your dealer may still have one in stock. If not, you may use the Miller type 1447. This is an unshielded slug-tuned FM antenna transformer. In this case, replace trimmer

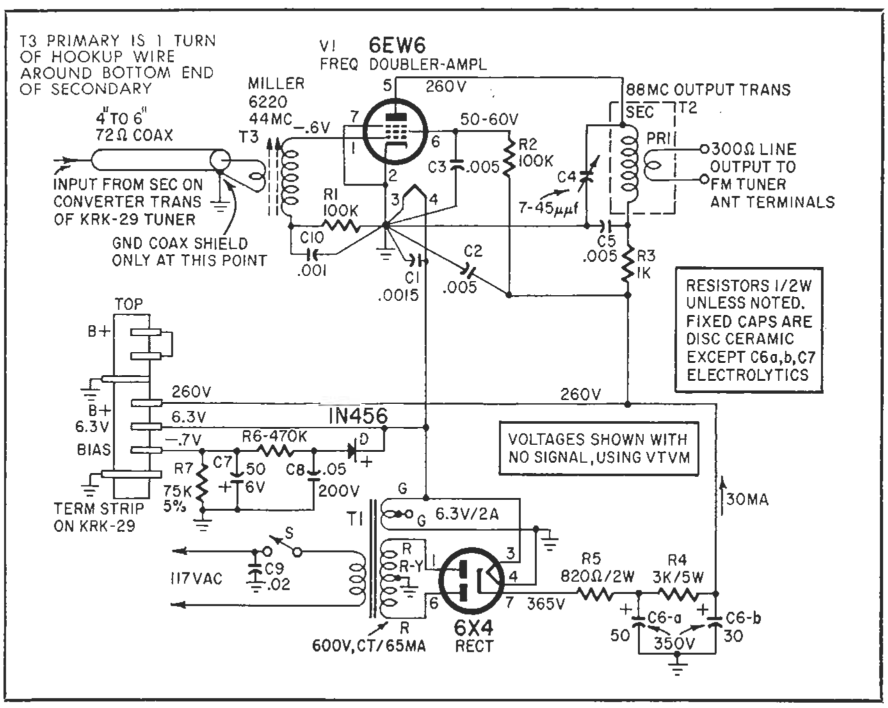


Fig. 2—Circuit for using RCA KRK-29 TV tuner.

C4 with a mica capacitor of around 25 μμf and peak the coil with the slug. Add a shield can (Miller S-32 or equivalent), if needed, for stability.

Power supply

B-supply voltage should be within 15% of the value shown on the schematics. However, the B-voltages applied to the TV front ends are *maximum* values and should not be exceeded, unless you plan to replace the tubes frequently!

We used a 600-volt center-tapped power transformer because our original unit required 260 volts for the KRK-29 tuner. The 6EW6 doubler–amplifier tube can operate with its plate voltage as low as 175 with only a slight reduction in gain. Since the Standard tuner needs a maximum of only 175 volts, you can substitute a lower-voltage transformer for T1, such as a 470 or 500-volt center-tapped 40-ma unit (Stancor PC8401, Triad R4A, etc.), and operate the 6EW6 plate at the same voltage as that supplied to the TV tuner (175 volts). In this event, omit R9.

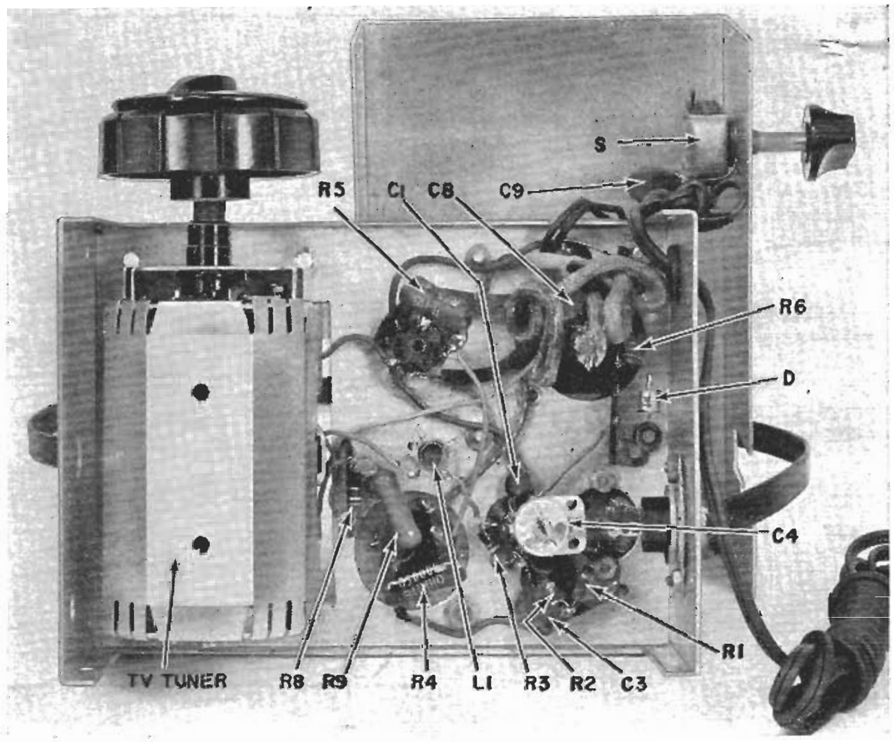
Alter the value of R5 by small amounts to set the B voltage at the proper value. We used a 2,000-ohm 5-watt potentiometer as a variable R5 in designing the converter. It was replaced with a fixed resistor after proper voltages were established and the correct value found for R5. (In some cases R5 may be unnecessary.)

Although we found it unnecessary to bias the tuner rf tube to prevent overloading at our location 25 miles from New York City, it may be necessary if you are close to a TV station. The bias arrangement shown in the schematics (silicon rectifier D and R6, R7, C7 and C8) provides a negative bias of about −0.75 volt. This is needed in the Standard tuner to prevent damage to the 6ER5. Although not strictly necessary if you use a cascode tuner such as the RCA KRK-29, it will extend the life of the 6BQ7-A with only a slight reduction in weak signal sensitivity. And this bias circuitry can be simply modified to provide up to −4 or −5 volts (by increasing the value of R7) if you need to reduce sensitivity to prevent overloading in very strong signal areas.

Alignment

The oscillator frequency on each channel of the front end must be raised by 2.75 mc (assuming that the front end was originally aligned to a sound i.f. of 41.25 mc, the commonest one used). (If you have a strong FM station on 88.1 mc, or one local TV station on channel 6—sound at 87.75 mc, you may select an i.f. slightly above or below 88 mc. Adjust the oscillator slugs and converter i.f. to the particular i.f. you select.) The procedure varies with different tuners. An *accurate* marker generator (preferably with a heterodyne detector) is essential.

Set the marker at the new oscillator frequency for each channel in turn (see chart). Place the converter



A look under the chassis.

in operation (with the 6EW6 i.f. tube removed), loosely couple an insulated wire from the rf input of the marker generator detector to the oscillator tube of the front end (loop the wire around the oscillator tube inside the shield and leave the tube shield in place). Tune the front end to the same channel that the marker is tuned to. Set the front-end fine-tuning control at its mid-point and *slowly* raise the front end's oscillator frequency by adjusting the oscillator slug at the front of the Standard tuner for less inductance. If you use other tuners, follow the manufacturers' instructions.

When the oscillator frequency reaches that of the marker, you will hear an audible beat through the marker's loudspeaker or headset. Adjust for zero beat. Then switch both marker and front end to the next channel and repeat the procedure until all channels have had the oscillator frequency raised 2.75 mc. *Do not touch the rf or mixer trimmers on the front end.*

On some channels it may be necessary to change the fine-tuning control setting to a point near one end or the other of its travel to hit the new frequency. In my case this occurred only on channel 2 which comes in near the counterclockwise position. Next

Oscillator Frequency Alignment Chart

Chan.	Sound Chan. (mc)		Osc. Freq. (mc) for 44-mc if
2	59.75	+ 44 mc =	103.75
3	65.75	+ 44 mc =	109.75
4	71.75	+ 44 mc =	115.75
5	81.75	+ 44 mc =	125.75
6	87.75	+ 44 mc =	131.75
7	179.75	+ 44 mc =	223.75
8	185.75	+ 44 mc =	229.75
9	191.75	+ 44 mc =	235.75
10	197.75	+ 44 mc =	241.75
11	203.75	+ 44 mc =	247.75
12	209.75	+ 44 mc =	253.75
13	215.75	+ 44 mc =	259.75

(uhf channels follow same procedure.)

insert the 6EW6 i.f. amplifier–doubler tube and tune the marker to 44 mc.

Feed the 44-mc signal into the TV front-end mixer grid through the usual grid "look-in" point. Connect a vtvm with a crystal demodulator probe to the plate of the 6EW6. Adjust the i.f. slug on the front end (Fig. 1) for maximum output. Do the same with the slug on L (Fig. 1) (T3 on Fig. 2). Next, connect the crystal demodulator probe across the 300-ohm secondary of T2 and adjust C4 for maximum output. (If a sweep generator and oscilloscope are available, a more accurate alignment can be performed in conjunction with the marker generator.)

Operation

Connect the TV antenna to the converter's antenna terminals. (In my location, an outdoor FM antenna works well as the source of TV signals for the converter.) Connect T2's secondary through a length of 300-ohm lead to the FM receiver's antenna terminals. Tune the FM receiver to 88 mc (make sure your receiver dial calibration is accurate and that you are actually tuned to the converter's intermediate frequency). Now set the converter channel changer to the desired TV channel and adjust the fine-tuning control till the TV sound comes out of the speaker of your FM set.

That's all there is to it! There is no output unless the converter is tuned to a TV station. Adjust volume at the FM set. At some settings of the converter fine-tuning control you may hear buzzing. You are tuning in the video portion of your TV station. CAUTION: If your FM set has warmup drift, it may be necessary to retune to 88 mc after warmup to insure good reception from the converter. The converter itself may show a small amount of warmup drift, too, particularly on the high band.

One final point. If one of your TV stations is on channel 6, you may have difficulty receiving it with this unit. Channel 6 sound transmission is at 87.75 mc, very close to our 88 mc i.f. You *may* have feedback from the converter output to input. However, most FM tuners can tune in channel 6 directly without a converter. In this case, you may have to listen to channel 6

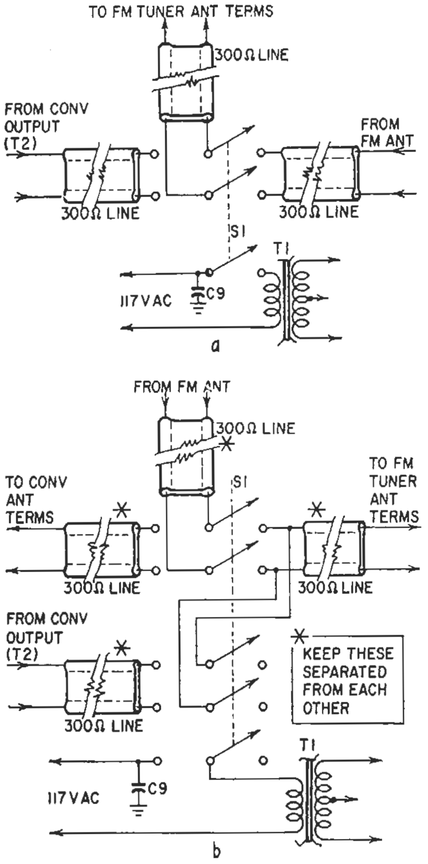


Fig. 3—Two options for making the unit more flexible: a—Combination antenna–power switch bypasses the converter and connects the antenna directly to to the FM tuner when the converter is turned off. b—This switching circuit is used if you can use your FM antenna with the converter.

directly and other channels through the converter. In our case we had no difficulty in receiving channel 6, Philadelphia (about 60 miles distant), on the converter.

Two minor refinements can be added by the perfectionist—a pilot light to remind you that the converter is on, and a combination antenna transfer-power switch which will bypass the converter and connect the FM antenna directly to the FM tuner in the *off* position (Fig. 3-a). The TV antenna is used for the converter input.

If you find it possible to use your FM antenna with the converter, use the circuit of Fig. 3-b.

With this unit you will find that TV sound will be of as good quality as the output of your FM tuner. It will be limited only by the fidelity of your TV station's sound, which, like the little girl, is very good indeed when it's good, but when it's bad it's terrible! END

TV SOUND CONVERTER

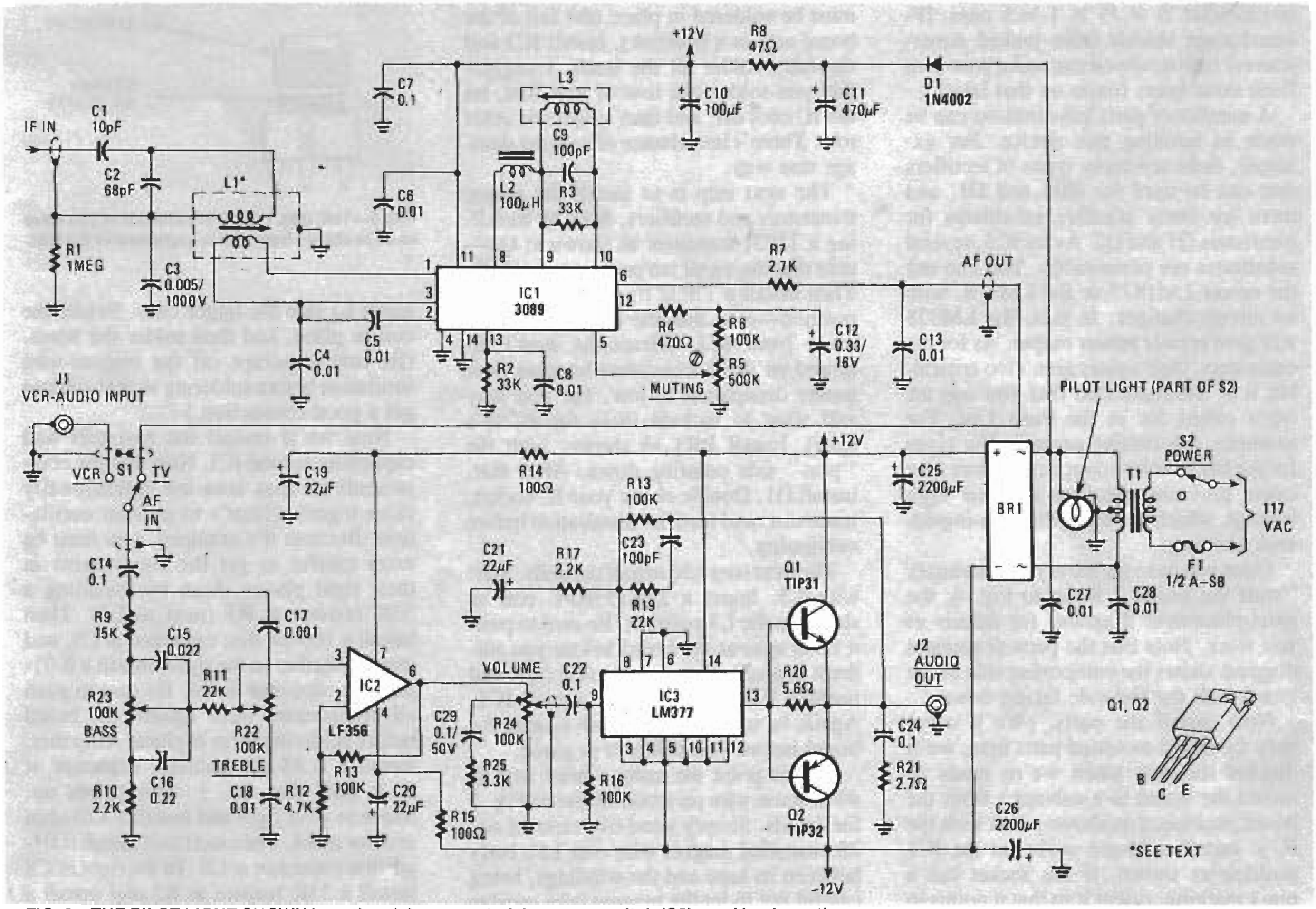


FIG. 2—THE PILOT LIGHT SHOWN is optional. It was part of the power switch (S2) used by the author. Note that R18 (connected between C23 and R19) is incorrectly labelled R13.

C21, C23, and R19 shape the frequency response.

All that's left are the power supplies (+12 and −12 volts). The amplifier section uses a conventional ± 12-volt supply, made up of T1, BR1, C25, and C26. The IF section has its own 12-volt power supply: D1, C11, C10, and R8. A separate supply is needed for that section because it was found that powering it from the same supply used by the amplifier generated noticeable hum.

Construction

The first step in building the TV Sound Converter is to obtain or make a PC board. You can make your own board—the full-size foil pattern is shown in Fig. 3. A pre-etched and drilled board is available (from the supplier indicated in the Parts List). Whichever you choose, you should note that, because of the high sensitivity of the IF amplifier, a PC board is a necessity for this project. If you try to breadboard the device, the chances are that it will oscillate and do other strange things. Play it safe and use a PC board!

Once you have a board, the next step is to obtain the parts. Generally, they should be available from many sources. As for the Miller coils, they should be available from larger parts-distributors. Shields are required for those coils—you can use

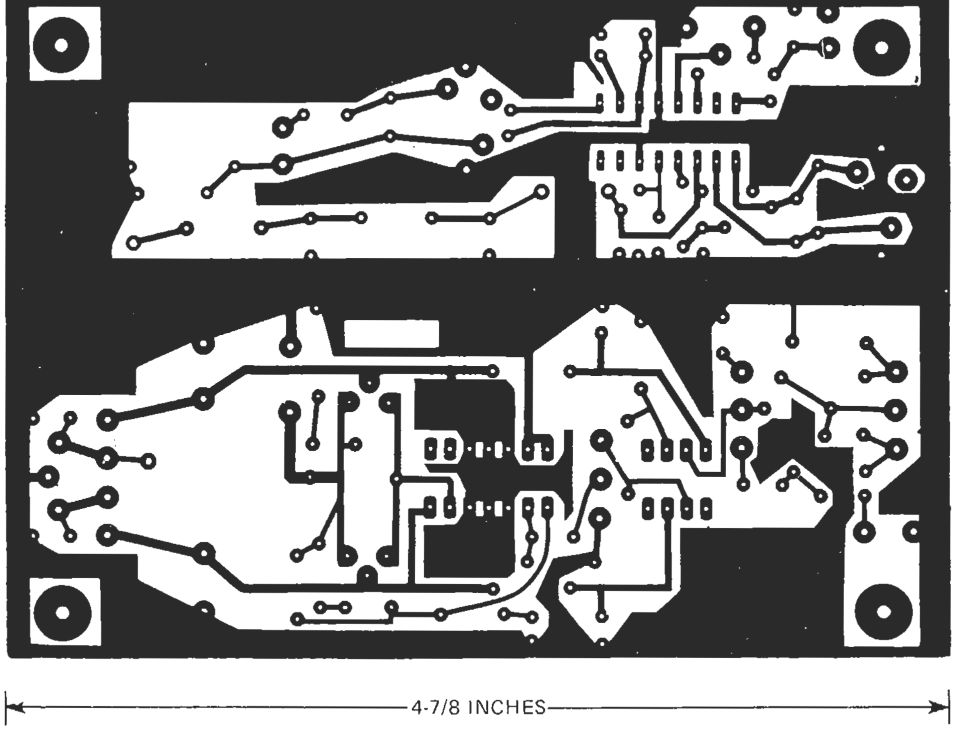


FIG. 3—YOU MUST USE A PC board for the converter. If you don't, the chances are that the circuit will oscillate.

commercial ½ × ½ × 1-inch ones, IF-transformer shields from junked American car radios, or you can make your own from sheet brass (more on that later).

A number of parts substitutions can be made in building this device. For example, there are many types of rectifiers that can be used for BR1 and D1, and there are many possible substitutes for transistors Q1 and Q2. As for IC3, several substitutes are permissible: You can use the newer LM1877 or the LM378, with no circuit changes. In fact, the LM378 will give greater power output. As for the capacitors, their values aren't too critical, but it is recommended that you use the types called for in the Parts List. For example, substituting ceramic-disc types for the Mylar tone-control capacitors may cause problems because of their high leakage, which can upset the high-impedance circuitry.

Once you have the parts you can simply "stuff the board." Refer to Fig. 4, the parts-placement diagram, for details as you work. Note that the parts-placement diagram shows the component side of the board with the foil side facing down.

Now install the parts. (We'll cover only the board-mounted parts here; we'll discuss the rest when we're ready to mount the board in a cabinet.) With the board positioned as shown, start with the IC's: Install a 16-pin socket at the IC1 position as shown. If the socket has a pin-1 marking, orient it so that it points to your right. Then go to the IC2 position and install an 8-pin socket. Be sure to orient any pin-1 marking as shown. Do not install either IC1 or IC2 until you are told to do so. Move on to IC3. *Do not* install a socket at this position; the IC must be soldered in place (the foil of the board acts as a heatsink). Install IC3 and carefully solder all the leads. I suggest that you solder one row of pins first, let the IC cool off, and then solder the other row. There's less chance of causing damage that way.

The next step is to install the power transistors and rectifiers. Start by installing a TIP31 transistor as shown at Q1—note that the metal tab points toward IC3. Then install a TIP32 transistor at the Q2 position—note that the metal tab points *away* from IC3. (Heatsinks aren't required on those transistors because their power dissipation is low, but you may still want to include them for safety's sake). Install BR1 as shown, with the "plus" side pointing down. After that, install D1. Double check your IC socket, transistor, and rectifier installation before continuing.

The next step is to install the coils. Start with L3. Insert a 23A155RPC coil as shown in the L3 position. Be sure to push it flush against the board before you solder it in place. Then move to the right and install a 100 μH choke (L2) against IC1. Again, be sure to push it flush against the board before you solder it in place.

At this point we make a brief stop to wind some wire on a coil. Refer to Fig. 5 for details. Simply wind five turns of no. 28 enameled magnet wire over L1's body between its base and the windings, being careful not to let the magnet wire overlap the existing winding. Then twist the free ends of the new winding once to hold them in place. Now refer back to Fig. 4. You are going to install the coil at the L1 position. Insert the wires of the coil you wound in the two small holes and then

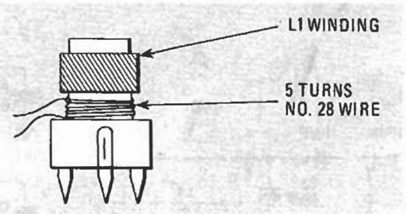


FIG. 5—THE ONLY COIL WINDING that you have to do is shown here and is explained in the text.

insert L1 into the larger ones. Solder the coil in place, and then solder the wires. (Be sure to scrape off the magnet-wire insulation before soldering so that you can get a good connection.)

Now we'll install the resistors and capacitors around IC1. Note that the components in that area are intentionally close together; that's to prevent oscillation. Because it's cramped, you must be extra careful to get the components in their right places. Start by installing a 33K resistor at R3 (next to L3). Then install a 100-pF disc capacitor at C9, and moving farther to the right, install a 0.01-μF disc capacitor at C6. Be sure to push all components flush against the board before soldering them in place. After that, install a 0.33-μF tantalum capacitor at C12; note that the + sign points up. Move to your right and install a 470-ohm resistor at R4. Then next to it install 0.01-μF disc capacitor at C8. To the right of C8 install a 33K resistor at R2 and install a 0.1-μF disc capacitor at C7. Finish up work in this area by installing a wire jumper at "J." A piece of leftover resistor-lead will work fine. Now, stop and examine your work, and correct any mistakes you may find before going on.

Continuing with the IC1 components, install a 0.01-μF disc capacitor at C13 and a 2.7K resistor at R7. Next to it, at R5, install a 500,000-ohm trimmer potentiometer. Move to the right and install 0.01-μF disc capacitors at C4 and C5. Finish up the circuitry around IC1 by installing a 100,000-ohm resistor at R6 as shown. Note that R6 is installed about an inch over the top of the IC. Place short lengths of insulated tubing over the leads and then install them in the places shown. That takes care of IC1; on to the less-critical circuitry!

The remaining resistors are installed next, starting at the left-hand side of the board and working toward the right. Begin by installing a 2.2K resistor at R10 and a 22K resistor below it at R11. Move down a bit and install a 15K resistor at R9 and then jump over to IC2 and install a 4,700 ohm resistor at R12, and a 100K resistor at R13. After that, install a 100-ohm resistor at R15, above IC3. On the other side of IC3 install a 100K resistor at R16 and, next to it, install a 100-ohm resistor at R14. After that, install a 2.2K resistor at R17. Move up to the center of the board and install a 47-ohm resistor at R8. Move up still farther and install a

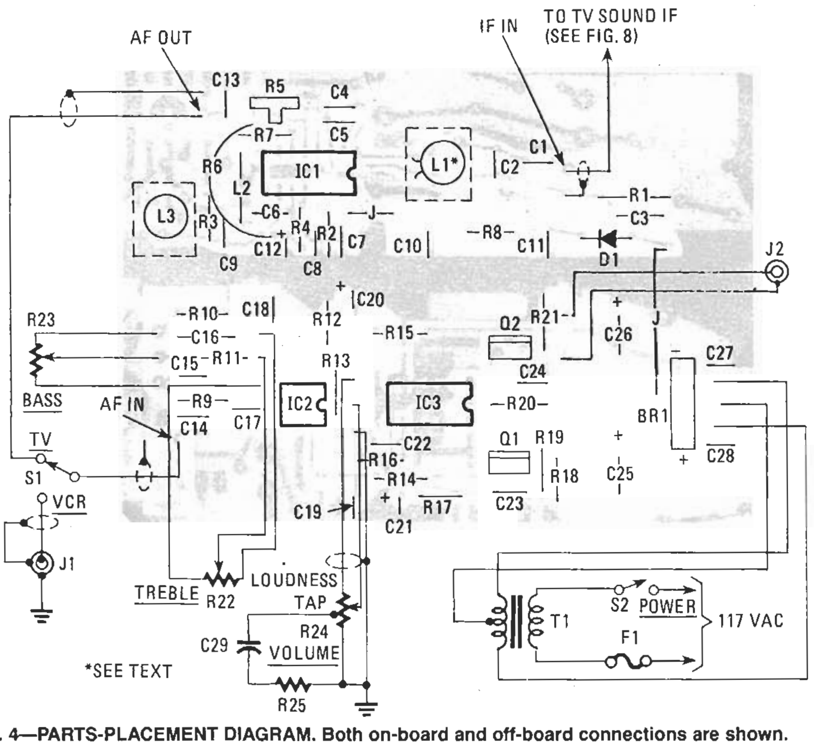


FIG. 4—PARTS-PLACEMENT DIAGRAM. Both on-board and off-board connections are shown.

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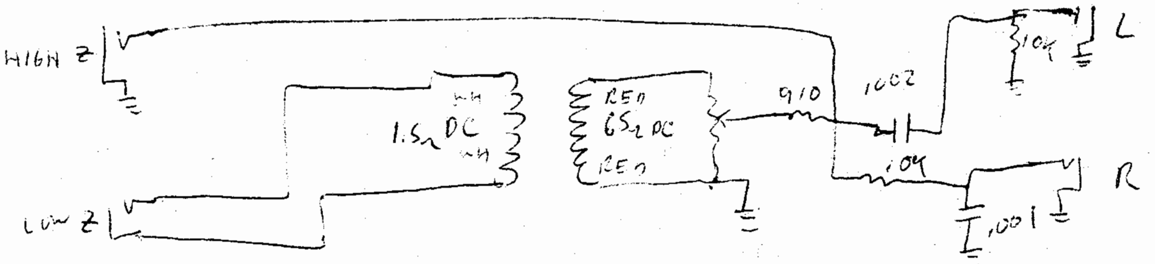

OUT OF TUNE

In "Enhance TV Sound with Stereo" (May 1982), the resistance for *R24* and *R25* in the Parts List should have been 390 ohms, as it was on the schematic.

In "Learning Quizes for Electronics" (June, p 70), in the Digital Counter Quiz, the note reading "FF_1 is initially turned on" should have been with part 2 of the quiz not part 1.