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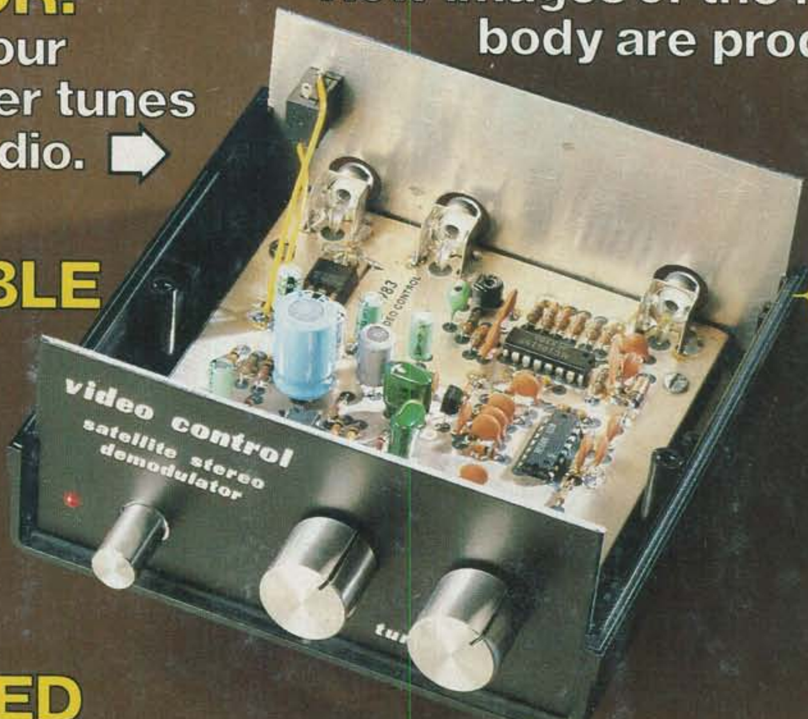

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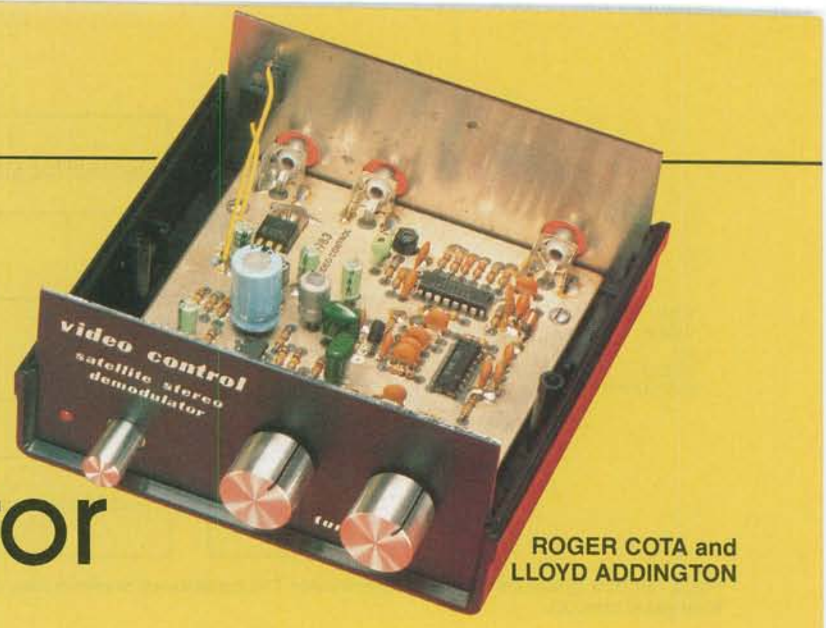


ROGER COTA and
LLOYD ADDINGTON

A stereo demodulator is a must for any TVRO-system owner who wants full enjoyment of his system. You can't receive stereo satellite broadcasts on your TVRO? Build this and hear what you've been missing!

ANYONE WITH A TELEVISION RECEIVE only (TVRO) home satellite system can now receive TV and audio broadcasts in stereo! If you integrate a satellite stereo demodulator into your present monaural system, you'll be able to enjoy stereo movies at home—without the hassle, expense, and crowds of a movie theater. And it wont cost any more than just a few trips out to the movies!

Much of the programming beamed to us from satellites is in stereo. That includes movies, music videos, and audio-only programming on *The Disney Channel*, *Bravo*, *The Movie Channel*, *The Nashville Network*, *MTV*, and more. In fact, stereo broadcasting is quickly becoming the norm.

Many of the more-recent satellite receivers have stereo capability built in. But if you want to add stereo capability to a monaural receiver that you already own, you can end up spending anywhere from \$300 to \$1100 for a commercially available demodulator.

But there is a less expensive alternative—you can build a stereo processor for less than \$80. And not only is the device we'll describe inexpensive, it's also easy to build and easy to operate. And it allows you to hear those movies, music videos, etc, the way that they were meant to be heard—in stereo.

We shouldn't forget to emphasize that this add-on will also let you listen—in stereo—to the many audio-only broadcast services that are present on a number of transponders on various satellites. Table 1 lists some of sources of video transmissions with stereo audio, while Table 2 lists audio-only stereo services.

The satellite stereo demodulator offers both discrete and matrix capabilities, tunable left and right channels, and an input that can receive either the raw video signal or the audio subcarrier signal from a mono satellite receiver.

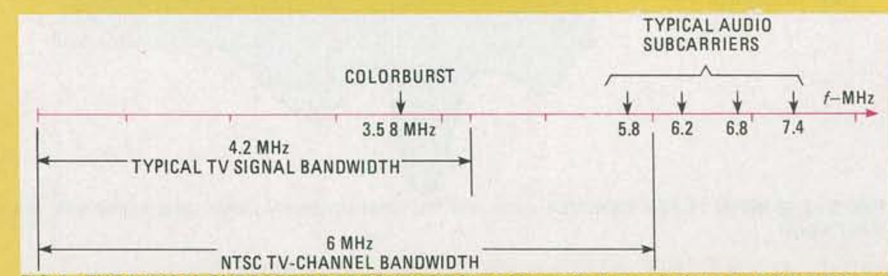


FIG. 1—THE TYPICAL SUBCARRIER FREQUENCIES used for audio transmissions are 5.8, 6.2, 6.8, and 7.4 MHz.

The stereo demodulator

The effective bandwidth of a satellite transponder is about 10 MHz. Since standard NTSC signals have a bandwidth of 6 MHz, there is ample room for audio subcarriers from 6 to 10 MHz of the transponders spectrum. Any subcarrier located above about 5.8 MHz can be used to carry additional audio programming. As shown in Fig. 1, 5.8, 6.2, 6.8, and 7.4 MHz are the most frequently used subcarrier frequencies. But in order to effectively obtain the desired stereo effect, the frequency-modulated audio subcarriers must be separated from the video. And that's why we need a stereo demodulator.

Figure 2 shows a block diagram of the satellite stereo demodulator. An incoming video or audio signal enters the first amplifier stages where it is filtered, amplified, and limited. The result, as shown in Fig. 3, is a hard-limited, noise-free FM signal with the video portions removed. The subcarrier signals proceed to two phase-locked loop sections.

One phase-locked loop IC is used for each stereo channel. Each is configured to cover the range from 5 to 8 MHz. A varactor diode is used to determine each center frequency. (A varactor is a voltage-variable capacitor formed from a diode in which the inherent capacitance is emphasized, instead of minimized as in a "normal" semiconductor diode.) The bias voltages for the varactor diodes are independently controlled by the front panel TUNE A and TUNE B controls. Increasing the voltage increases the frequency of the phase-locked loop.

The audio that is output by each PLL IC's is then lowpass filtered by de-emphasis circuits, applied to gain stages, and then sent to the matrix circuit, which is controlled by the front-panel-mounted DISCRETE/MATRIX selector.

Most of the stereo-audio subcarriers are

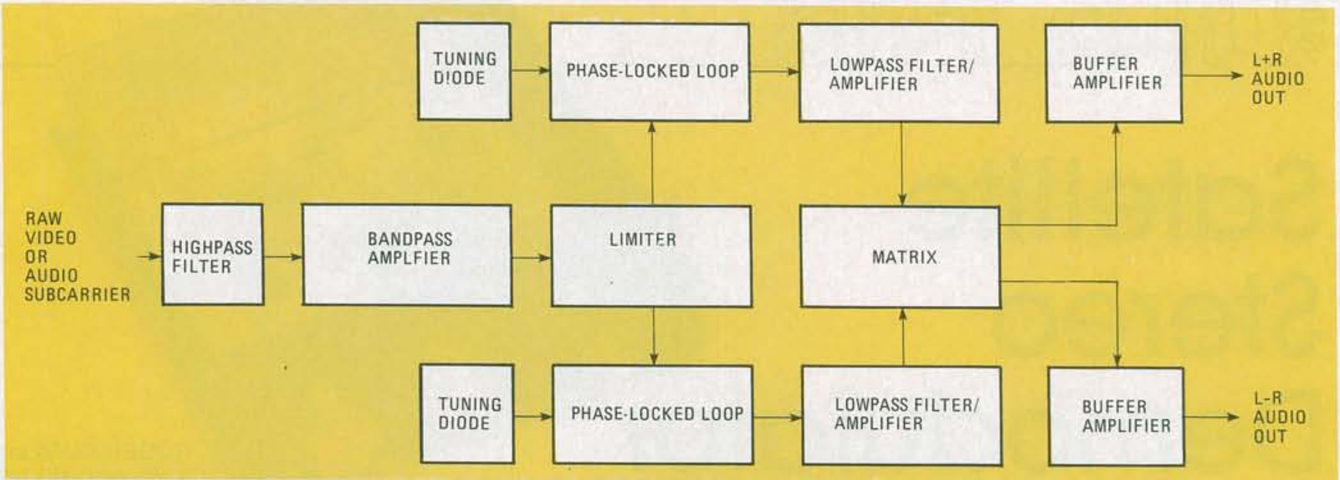


FIG. 2—BLOCK DIAGRAM OF stereo demodulator. The capacitance of each tuning diode is varied by front-panel controls.

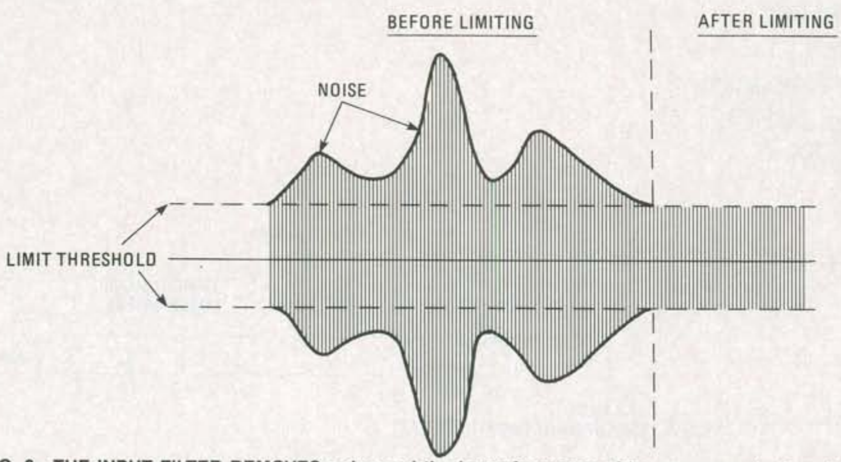


FIG. 3—THE INPUT FILTER REMOVES noise and the lower-frequency video components from the input signal.

TABLE 1—STEREO VIDEO-PROGRAMMING

Satellite	Transponder	Service	Subcarrier A (MHz)	Subcarrier B (MHz)	Mode
SATCOM F3	4	Spotlight	5.8	6.2	Discrete
SATCOM F3	5	The Movie Channel	5.8	6.8	Matrix
SATCOM F3	11	MTV	5.8	6.62	Matrix
SATCOM F3	16	HTN Plus	6.8		Multiplex
SATCOM F4	6	Bravo	5.8		Multiplex
SATCOM F4	8	Entertainment Channel	5.94	6.12	Discrete
WESTAR F5	10	Disney Channel	5.8	6.8	Discrete
WESTAR F5	12	Disney Channel	5.8	6.8	Discrete
WESTAR F5	17	Nashville Network	5.58	5.76	Discrete

TABLE 2—STEREO-AUDIO PROGRAMMING

Satellite	Transponder	Service	Subcarrier A (MHz)	Subcarrier B (MHz)	Mode
SATCOM F3	3	Moody Broadcasting	5.2	7.92	Discrete
SATCOM F3	3	Country Coast to Coast	5.58	5.76	Discrete
SATCOM F3	3	Star Station	5.94	6.12	Discrete
SATCOM F3	3	WFMT-FM	6.3	6.48	Discrete
SATCOM F3	3	Bonneville Broadcasting	7.38	7.56	Discrete
SATCOM F3	3	Stardust	8.05	8.14	Discrete
SATCOM F3	3	Music in Air	5.4	5.94	Discrete
SATCOM F3	3	Music in Air	5.58	5.76	Discrete
SATCOM F3	8	Cable Jazz Network	5.94	6.12	Discrete
SATCOM F4	7	Family Radio (East)	5.58	5.76	Discrete
SATCOM F4	7	Family Radio (West)	5.94	6.12	Discrete
ANIK D1	18	CIRK	6.17		Multiplex

transmitted either in *discrete* or *matrix* modes. In the discrete mode, one subcarrier contains only the left-channel information and another subcarrier contains only the right-channel information. In the matrix mode, each subcarrier contains a combination of the left- and right-channel information: One subcarrier contains the sum of the two signals (left + right or L + R) and the other subcarrier contains the difference of the two signals (left − right or L − R). The matrix circuit adds and subtracts those signals at the appropriate levels to separate out the two stereo channels. Those left- and right-channel signals are then amplified and presented at their respective output jacks.

A closer look at the circuit

Now that we've gone over the basics of what the circuit does, let's look at it in more detail. Refer to the demodulator schematic in Fig. 4.

The input to the demodulator—either the raw-video output or the subcarrier output from the satellite receiver—is fed to the VIDEO IN jack, J1. From there, the input signal passes through a highpass filter made up of C35 and R40. That leaves the audio subcarriers unattenuated but rolls off any video components that might be in the signal. The signal then enters IC2, a 10116 ECL triple line receiver. That device contains three amplifier stages that are used to amplify, filter, and limit the signal.

After passing through the first amplifier stage of the IC, the signal is filtered through L1 and C1. That series L-C circuit is tuned to 6.5 MHz, the center of the subcarrier spectrum. Resistor R38 presents a 75-ohm load for the tuned circuit (to give the appropriate Q factor).

The input to IC2 is biased up through a bias pin (pin 11) and R43. The signal then enters the next stage of the op-amp, exits at pin 15, and passes through a tuned circuit made up of C13 and L2. That circuit is also tuned to the center of the subcarrier-frequency band (6.5 MHz). At that point, the signal has been amplified and limited by IC2 to 1-volt peak-to-peak. All the

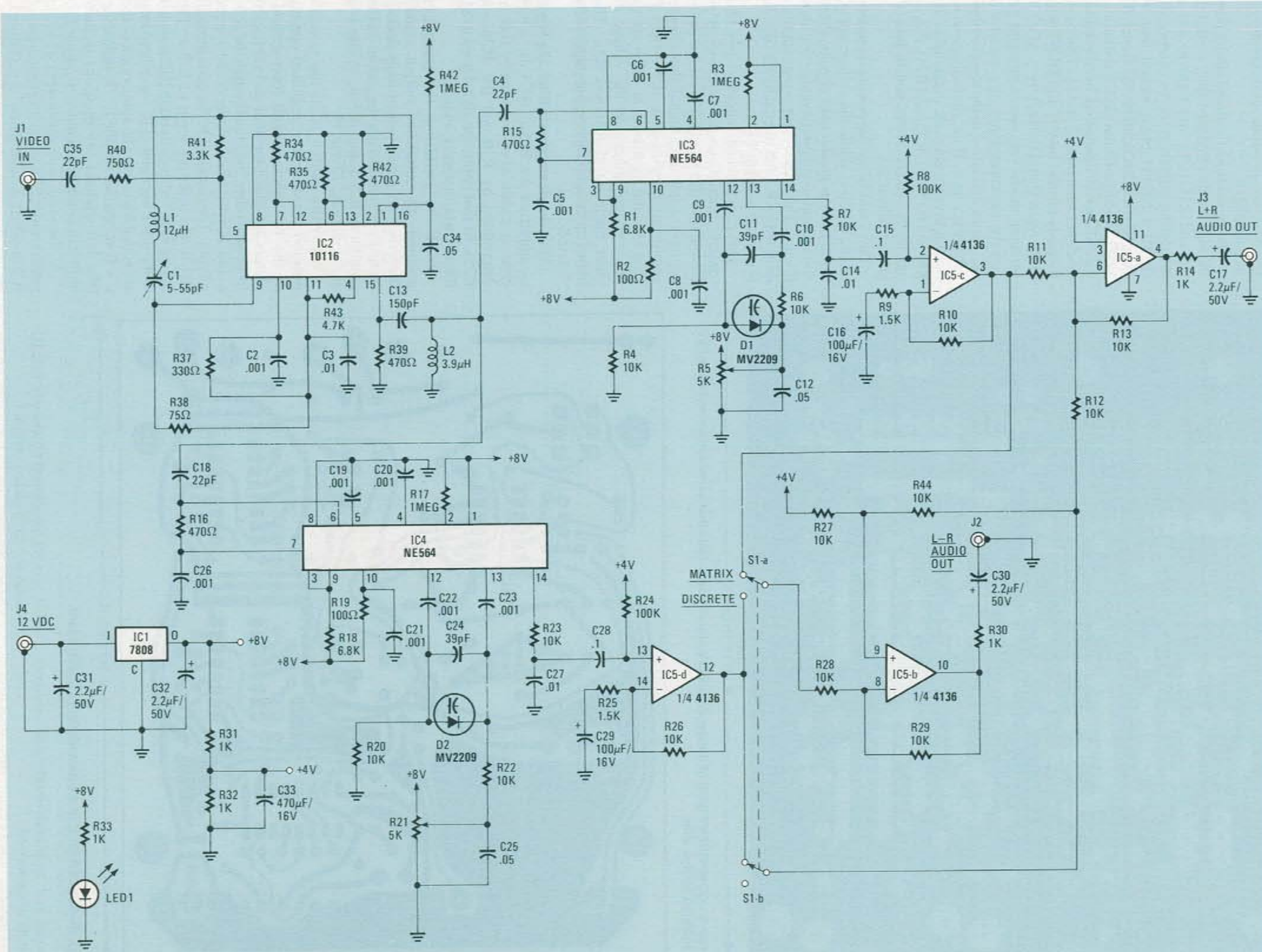


FIG. 4—SATELLITE STEREO DEMODULATOR SCHEMATIC. The frequency of each PLL is determined by the capacitance of a varactor diode (which is controlled by R5 and R21).

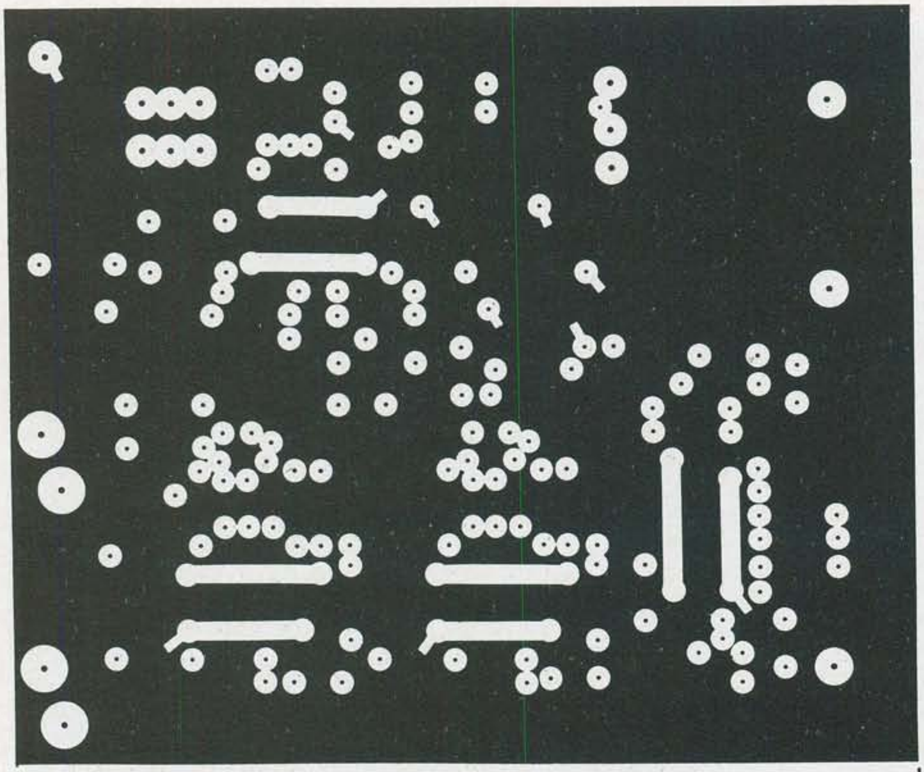


FIG. 5—COMPONENT SIDE of the demodulator's circuit board. Note that some components must be soldered on this side.

FIG. 6—SOLDER SIDE of the demodulator's circuit board.

noise and amplitude-modulated components are removed.

From the tuned circuit, the signal passes to the demodulator PLL IC's (IC3 and IC4). As we mentioned previously, one IC is used for each stereo channel.

Note: Because the PLL circuits are essentially the same, we will discuss only one set of components. We will, however, list the corresponding set of components in parenthesis.

The signal from the tuned circuit passes through another highpass filter made up of C4 and R15 (C18 and R16) to roll off interfering signals prior to entering IC3 (IC4), a NE564 phase-locked loop IC. That IC then demodulates the signal. The VCO (*V*oltage-*C*ontrolled *O*scillator) in the NE564 is controlled by the capacitance between pins 12 and 13. That capacitance is formed by C11 and D1 (C24 and D2). Note that D1 (D2) is a MV2209 varactor diode. As we mentioned previously, the capacitance of a varactor diode varies in relation to the reverse-biased voltage across it. Here, that voltage comes from a divider network made up of R4, R6, and R5 (R20, R22, and R21). Potentiometer R5 (R21) allows you to tune the proper subcarrier.

Pins 1 and 10 are the power connections on the NE564. While the voltage applied to pin 1 can be greater than 12 volts, the the voltage applied to pin 10 cannot rise above 6 volts. Thus, the 8-volt power supply is dropped by R2 and filtered by C8 to give a 5-volt input to pin 10.

The demodulated output at pin 14 is lowpass filtered (or de-emphasized) via R7 and C14 (R23 and C27). At that point, we have a low-level signal that requires amplification by op-amp IC5-c (IC5-d). That op-amp is biased at one-half the power-supply voltage by the voltage divider made up of R31 and R32. That biases up the amplifier output stages to the +4-volt level.

After the de-emphasis filter, the signal is amplified by IC5-c (IC5-d), which gives it a gain of approximately 6.6, as determined by R10 and R9 (R26 and R25). At that point, the signal goes to S1, the MATRIX/DISCRETE switch.

With the switch in the DISCRETE position, the amplified output signals from the two phase-locked loop demodulators are run through the output buffer amplifiers IC5-a and IC5-b, to the two audio outputs, J2 and J3.

When the switch is in the MATRIX position, however, the amplified outputs of the two phase-locked loop demodulators are added together and subtracted from each other, then run through the IC5-a and IC5-b, which perform the matrix mixing. The output of IC5-c goes through R11 to the inverting input of IC5-a. The output of IC5-d goes through R12 and also to the inverting input of IC5-a, where they are added together. The summation of the L + R subcarrier and the L − R subcarrier (the left-channel information) is then buffered, amplified, and fed to output J3.

At the same time, the output of IC5-c goes through R28 to the inverting input of IC5-b where a subtraction is performed, giving an output of the L + R subcarrier

continued on page 114

SATELLITE STEREO

continued from page 54

PARTS LIST

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

R1, R18—6800 ohms
R2, R19—100 ohms
R3, R17—1 megohm
R4, R6, R7, R10–R13, R20, R22, R23, R26–R29, R44—10,000 ohms
R5, R21—5000 ohms, linear-taper potentiometer
R8, R24—100,000 ohms
R9, R25—1500 ohms
R14, R30–R33—1000 ohms
R15, R16, R34, R35, R39, R42—470 ohms
R36, R38—75 ohms
R37—330 ohms
R40—750 ohms
R41—3300 ohms
R43—4700 ohms

Capacitors

C1—5–55 pF trimmer capacitor
C2, C5–C10, C19–23, C26—0.001 μF ceramic disc
C3, C14, C27—0.01 μF, ceramic disc
C4, C18, C35—22 pF, ceramic disc
C11, C24—39 pF, ceramic disc
C12, C25, C34—0.05 μF, ceramic disc
C13—150 pF, ceramic disc
C15, C28—0.1μF, Mylar
C16, C29—100 μF, 16 volts, electrolytic
C17, C30–C32—2.2 μF, 50 volts, electrolytic
C33—470 μF, 10 volts, electrolytic

Semiconductors

IC1—MC7808 8-volt regulator
IC2—MC10116 triple line receiver
IC3, IC4—NE564 phase-locked loop (Signetics)
IC5—μA4136 quad op-amp
D1, D2—MV2209 varactor diode
LED1—miniature red LED

Other components

L1—12 μH, high-Q
L2—3.9 μH, high-Q
J1–J3—RCA-type phono jacks
J4—miniature phone jack
S1—DPDT push-on/push-off

The following are available from Video Control, 3314 H. Street, Vancouver, WA 98663, (503) 693-3834: Complete kit including all parts, printed circuit board, chassis, AC power adapter, and manual $79.00; PC board and manual only, $19.50; AC power adapter, $10.00. Include $3.50 for shipping and handling for all orders.

minus the L – R subcarrier (the right-channel information).

Building the circuit

Because of the high frequencies involved, using a printed-circuit board is

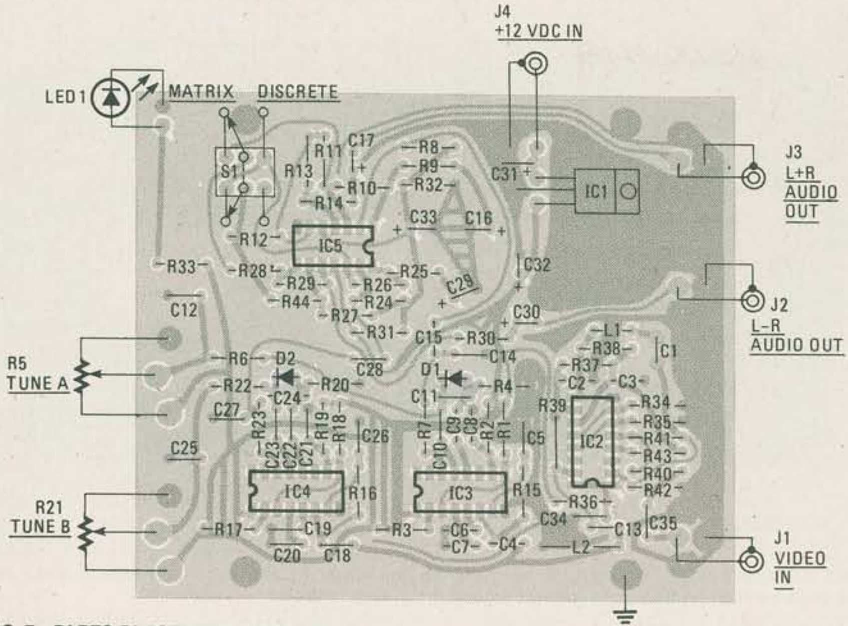


FIG. 7—PARTS-PLACEMENT DIAGRAM. Note that some parts are soldered on the component side as well as the "solder" side. While those places aren't specially marked, you will notice that the groundplane is not etched away in those places.

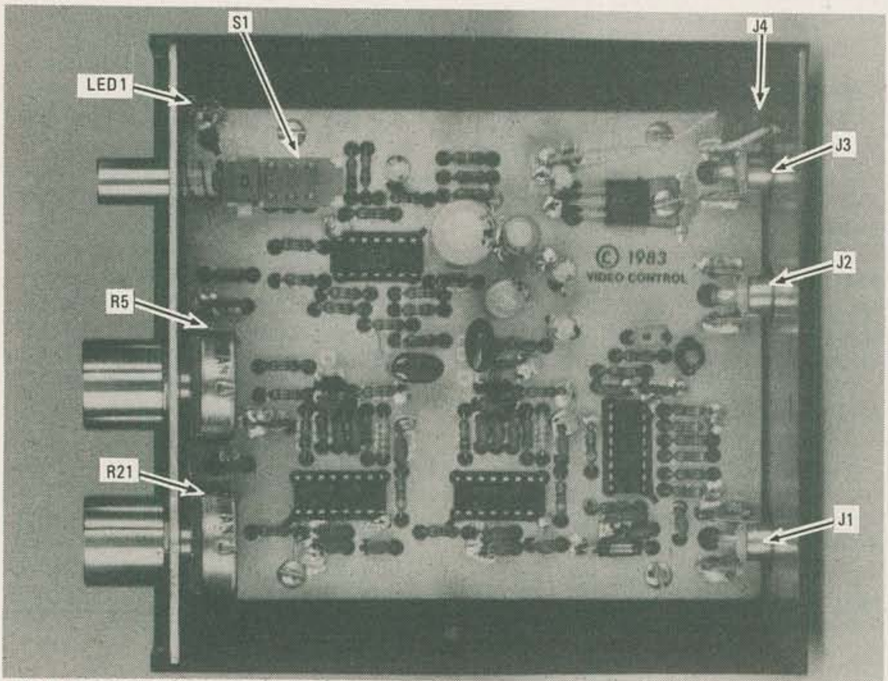


FIG. 8—TO KEEP LEAD LENGTHS SHORT, all the components (except for power-input jack J4) are mounted directly to the board.

essential. The component side of the PC board is shown in Fig. 5 while the solder side is shown in Fig. 6.

Since the circuit is composed of three active sections, with each section operating around the 6.5 MHz range, construction and circuit-board layout is very important. When soldering components to the board, lead lengths should be kept as short as possible to keep the very sensitive front-end (the amplifier in the input stage) from oscillating.

Notice that the component side of the board serves as a ground plane for shielding and reduction of crosstalk. Some of the components must be soldered to the ground plane as well as to the solder side. If you look at Fig. 7, the parts-placement diagram, that is evident wherever the component placement holes are touching the groundplane.

Since you want to keep lead lengths to a minimum, you should start soldering the low-profile parts (resistors, for example) onto the board first. If all of the parts are the same height, simply laying the board on a flat surface will press all the parts flush against the board and your lead lengths can be kept as short as possible. Next solder the higher profile parts such as

FIG. 9—FRONT-PANEL CONTROLS. To make the unit easier to use, you might want to mark the settings for your favorite transponders around the tuning controls.

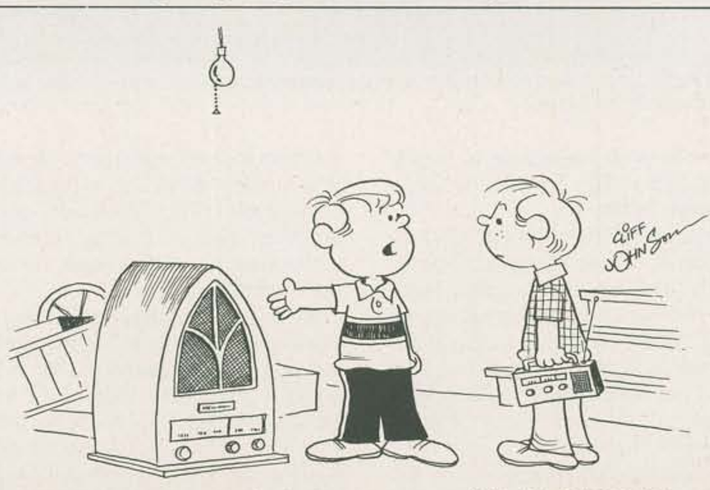
IC's. Do not use IC sockets when you install the IC's. Follow by installing the other components except LED1. (LED1 must poke through a hole in the front panel.)

Calibration

When your construction work is finished, apply power via a wall-mounted AC adapter, and connect the left and right audio-channel outputs to the appropriate stereo receiver/preamplifier audio inputs (AUX IN, for example). The next step is to test the unit by tuning in a satellite TV stereo transponder that has a strong video signal. A good one to start with is MTV (*M*usic *T*elevision)—you can be virtually certain of finding a stereo signal there. (MTV is on Satcom F3, transponder 11.)

To begin, turn up the stereo's volume to a moderate level to where the hiss is not too obnoxious. Push the DISCRETE/MATRIX switch, S1, in the DISCRETE position. Turn R5 (TUNE A) completely clockwise and R21 (TUNE B) completely counterclockwise. Now begin adjusting R21 clockwise until the L − R subcarrier is found. The phase-locked loop will lock onto the subcarrier when R21 is correctly positioned. You should hear a hollow or echo sound when properly locked onto the L − R subcarrier. Now C1 must be adjusted—using a non-inductive tool—until there is the least amount of noise present on the L − R subcarrier. Next begin turning R5 counterclockwise until the L + R subcarrier is located. The proper settings of the front panel controls will be evident when the L − R channel has a lot of "ambience" signals. In other words, it will sound hollow and echo. Now engage switch S1 to the MATRIX position (extended) and listen to the music blend in full stereo. Both TUNE controls (R5 and R21) can now be fine-tuned by ear.

When tuning in a discrete transponder, the procedure is identical, except leave the switch S1 in the DISCRETE (extended) position. Because the audio subcarriers on different transponders are often at different frequencies, you may need to fine-tune front-panel controls R5 and R21. **R-E**



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