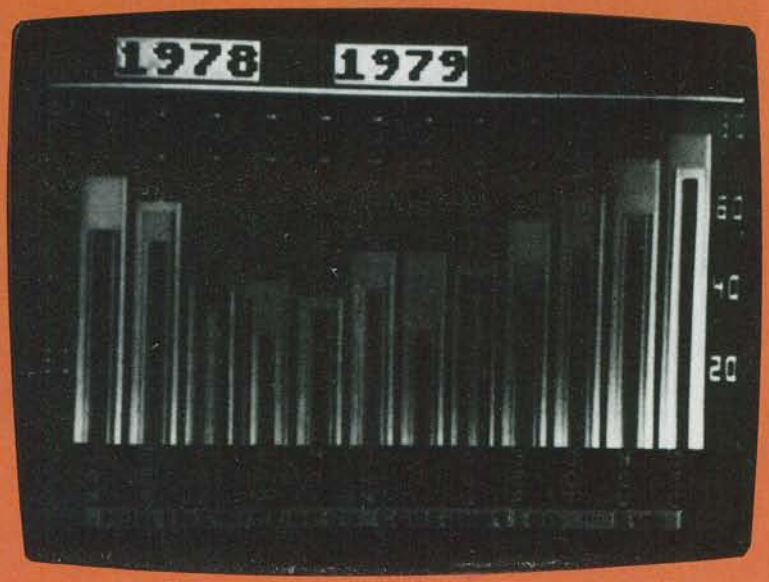
Modify your TV to include a direct video input for your computer or VCR—and still have it function as a receiver.

JOHN SOLUK



Add A Video Input To Your TV

ARE YOU ONE OF THE MANY THOUSANDS of owners of personal computers, VCR's, videodisc players, etc. whose eyes have been bothered because of color shift, signal beat, ghosts, and RF interference showing up on your TV screen? The source of your problem is probably the fact that you are RF-modulating the video signal from your device to get it into your TV set. Fortunately, there's a low-cost solution for you. With this easy-to-build direct-video modification for your TV set, you can rid yourself forever of the "RF syndrome."

Until recently, the most common and economical method of obtaining a display from a video source (computer, VCR, etc.) has been through an RF modulator, by means of which the video-source signal is fed through the antenna terminals of a standard TV set. By using a TV set in that manner—thereby eliminating the need to purchase an expensive display monitor—one could save hundreds or even thousands of dollars. However, as many users have come to realize, the RF-modulator method has several significant drawbacks. Most of the problems are related to RF radiation and the interference it causes, which degrade picture quality.

Theory of operation

In this direct-video modification, the tuner and IF sections of your set are bypassed. The video-source signal is injected directly into—or as close as possible to—the first-video-amplifier stage in your set. To provide electrical isolation between the input and output sections (both for safety and to protect your video source), two special-purpose opto-isolators (optical couplers) are used; there is no electrical connection between the two sections. One optoisolator is a wide-bandwidth coupler for the video channel; the other is a narrow-bandwidth device for the audio channel.

Figure 1 shows a block diagram of the system. The output section is powered directly from the set's own DC power supply. The input section has an on-board rectifier and is powered by inductively-coupled AC that you get by placing a few turns of insulated wire around the exposed ferrite core of the flyback transformer (we'll talk more about how to do that later).

A schematic of the direct-video modification board is shown in Fig. 2. The video signal is applied across R1 and is coupled via C1 to the Q1–Q2 power-driver stage. That transistor pair steps up the input-signal level enough to modulate the input LED (in IC1) and also provides a low impedance for best frequency response. Resistor R5 determines the amount of modulation drive-signal, and R6 and C2 provide additional boost at frequencies above 2 MHz for improved video response. The signal is coupled through C3 to the LED in optoisolator IC1. Resistor R7 provides the DC-bias point about which the input signal will be modulated.

Inside IC1 are an LED and a phototransistor that are optically coupled by a light pipe. There is no internal electrical connection between the two devices. The modulated light strikes the detector surface and the resultant current flow appears at pin 5 of IC1 with a signal being developed across R20. That signal is typically 200 to 300 mV peak-to-peak and requires amplification to bring it up to a

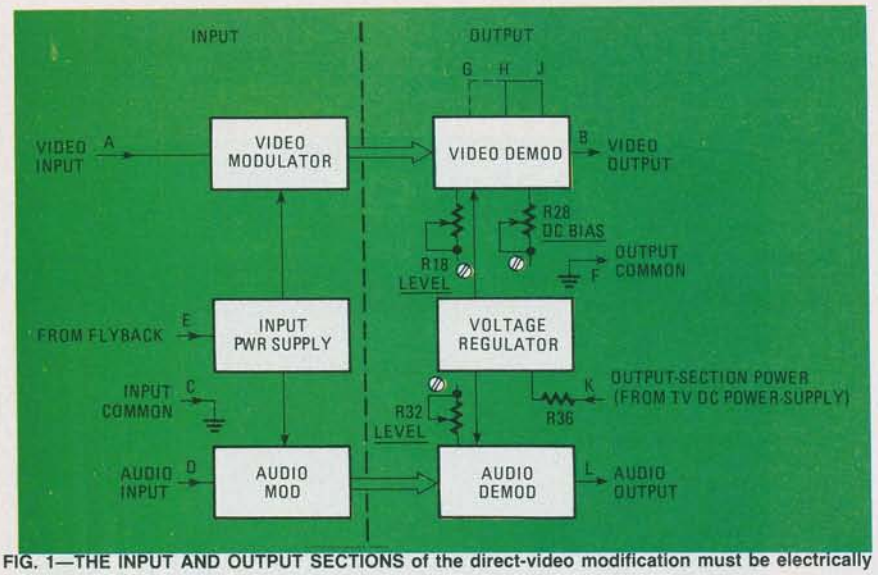


FIG. 1—THE INPUT AND OUTPUT SECTIONS of the direct-video modification must be electrically isolated.

usable level. Transistor Q5 performs that function. Resistor R18 sets the video-output level. The signal at that point is inverted with respect to the input and is coupled to Q6 through C9. The signals at the collector and emitter of Q6 are equal in amplitude but are inverted with respect to one another. Thus, an in-phase signal is available at pad "J" while the signal at "G" is out of phase. The signal with the desired phase is coupled through C12 and C13 to the output, where it is mixed with a DC component whose level is set by R28.

The audio portion of the circuit functions similarly. But, because of audio's narrower bandwidth-requirements, a simpler circuit is used. An audio signal is applied to C4. Transistor Q3 amplifies that signal and sets the DC-bias point for optoisolator IC2's LED simultaneously. Resistor R11 sets the drive-current range. The modulated light falling on the detector of IC2 produces an output current at pin 5. The output level is set by R32.

As mentioned earlier, to isolate the input and output sections, separate power supplies are used. The output section can usually take low-voltage DC directly from within the set, while the input section gets its power from inductive coupling to the TV's flyback transformer. A few turns of wire are wound around the flyback's ferrite core and the resulting signal is rectified and filtered by D3, R12, and C6. The voltage at that point will be approximately 12 volts, if two turns of wire are used.

Transistor Q4 and its bias network, along with LED1, form a low cost go/no-go indicator that is especially helpful for those who do not have an oscilloscope or VOM at their disposal. When the voltage is approximately 12 volts, LED1 will begin to glow dimly. If it glows too brightly, there are too many turns on the flyback and thus too high a voltage.

The output power is controlled by D4, a Zener diode that limits the voltage to the output stage to a maximum of 12 volts. Resistors R38 and R36 provide the voltage drop necessary to ensure safe operation of D4. The value of R36 depends

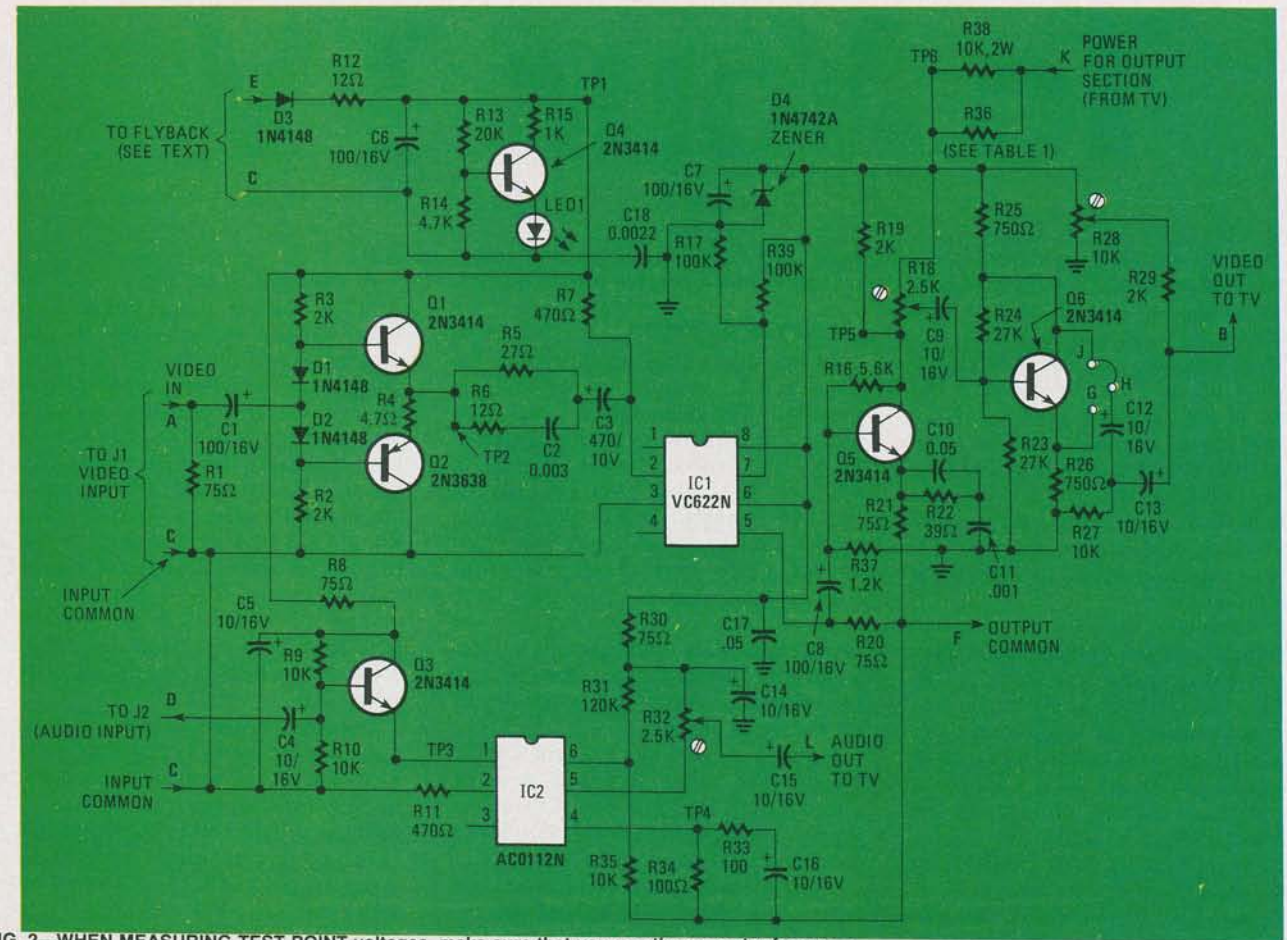


FIG. 2—WHEN MEASURING TEST POINT voltages, make sure that you use the correct reference—TP1-TP6 are measured with respect to "C" and all others are measured with respect to "F."

upon the value of the input voltage. See Table 1 for help in selecting a resistor of the correct value.

Construction

A foil pattern for a single-sided PC board is shown in Fig. 3, and a parts-placement diagram in Fig. 4. Install all components on the component (non-foil) side of the PC board. Start by inserting all of the resistors except R36 (that will be installed once we have determined the output-section power source). Next, install all of the capacitors as indicated, except for C16 (and R33), which can be installed later if your set requires a boost in audio output. Install the remaining components as shown in the parts-placement diagram. When mounting the transistors and diodes be sure to orient them correctly. Once you have completed the board assembly you can proceed to the next phase—converting the set.

TABLE 1

Receive-section input voltage	R36
10 to 11.9 VDC	Jumper
12 to 17 VDC	27 ohms, ½W
18 to 24 VDC	100 ohms, ½W
105 to 165 VDC	10K ohms, 2W

Set modification

As an example, we'll show the conversion process for a 13-inch Samsung color receiver. However, the process will work for any other set. Before you start tearing apart your TV, it would probably be a good idea (actually, it's just about essential) to get the appropriate Sams *Photofact* folder, which will provide you with a schematic for your model and show you where all the components are located.

With that in hand, several points will have to be located and marked off for future reference. Remove the back panel of your set so that you can find and verify those points. For your own safety, unplug the set and to discharge the high-voltage power supply prior to performing any work on it.

The first point to locate is the power source for the output section. Begin by finding the power supply on your circuit diagram. Most transistorized TV sets will either have a low- or high-voltage output (or both) present at the power supply, but a vacuum-tube set may have only a high voltage output. *Do not* use the 6.3-volts AC heater windings on tube sets for a power supply; the direct-video PC board requires DC, preferably 12 volts. By using Table 1 and choosing the appropriate resistance value for R36, you can use other DC source-voltages to power the converter board.

PARTS LIST

All resistors ¼-watt, 5% unless otherwise specified

R1, R8, R20, R21, R30—75 ohms
R2, R3, R19, R29—2000 ohms
R4—4.7 ohms
R5—27 ohms
R6, R12—12 ohms
R7, R11—470 ohms
R9, R10, R27, R35—10,000 ohms
R13—20,000 ohms
R14—4700 ohms
R15—1000 ohms
R16—5600 ohms
R17, R39—100,000 ohms
R18, R32— 2500 ohms, trimmer potentiometer, PC-mount
R22—39 ohms
R23, R24—27,000 ohms
R25, R26—750 ohms
R28—10,000 ohms, potentiometer, PC-mount
R31—120,000 ohms
R33, R34—100 ohms
R36—see text and Table 1
R37—1200 ohms
R38—10,000 ohms, 2 watts

Capacitors

C1, C6, C7, C8—100 μF, 16 volts, electrolytic
C2—.003 μF, 50 volts, ceramic disc
C3—470 μF, 10 volts, electrolytic
C4, C5, C9, C12, C13, C14, C15, C16—10 μF, 16 volts, electrolytic
C10, C17,— 0.05 μF, 50 volts, ceramic disc
C11—0.001 μF, 50 volts, ceramic disc
C18—0.0022 μF, 400 volts, ceramic disc

Semiconductors

IC1—VC622N wideband opto-isolator
IC2—AC0112N opto-isolator
Q1, Q3–Q6—2N3414
Q2—2N3638A
D1–D3—1N4148
D4—1N4742A 12-volt Zener
LED1—jumbo red LED
S1—DPDT miniature toggle switch (on–on), 125 volts, 3 amperes
J1, J2—phono, BNC, UHF, or phone jack

Miscellaneous: PC board, 75-ohm coax (RG-59/U), hookup wire, single- and two-conductor sheilded audio cable, hardware, etc.

The following are available from V.A.M.P. Incorporated, P.O.Box 411, Los Angeles, CA 90028: Complete kit with PC board and all components (DVM-1), $64.95; PC board and optoisolators (VC622N and AC0112N), $29.00; optoisolators only, $I9.95. Please add $2.00 for shipping and handling within U.S.A. Foreign orders please add $4.00. California residents please add 6% sales tax.

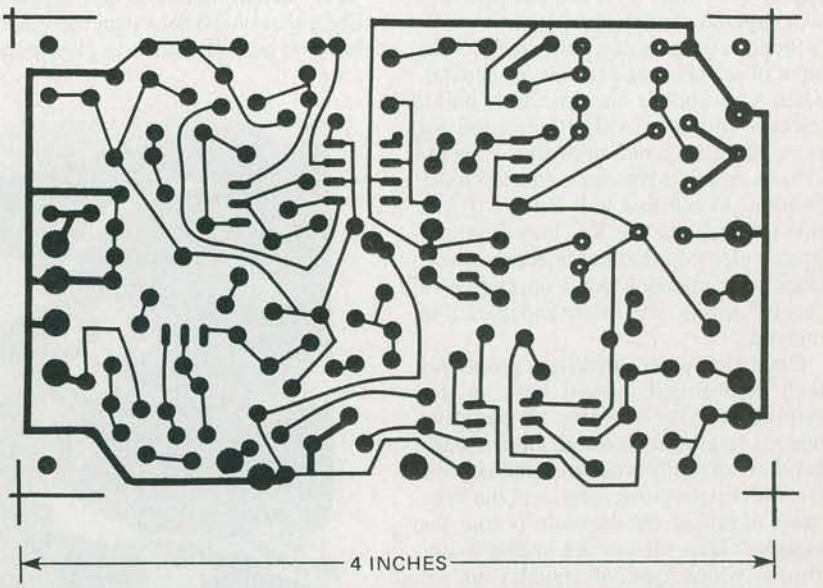


FIG. 3—SINGLE-SIDED PC BOARD is small enough to fit comfortably inside most TV sets.

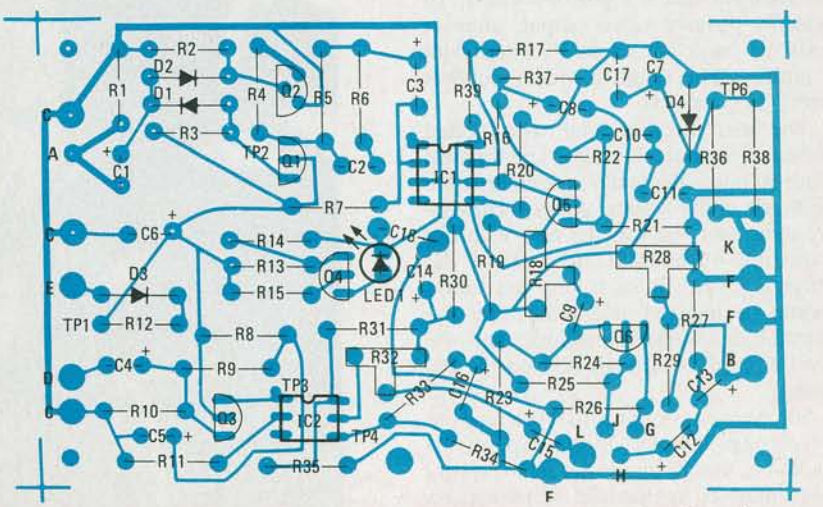


FIG. 4—ONLY THE BYPASS switch and input jacks are not contained on the circuit board.

For our Samsung set, we selected an input voltage of 12 volts. The appropriate value for R36—determined from Table 1—in our case was 27 ohms. Mark on your circuit drawing the point from which you will tap your power and then find that point in your set. Be sure that your value for R36 is correct, and install the resistor on the PC board. Then strip one end of a three-foot length of red wire and connect it to pad "K" on the PC board. Connect a similar length of black wire to pad "F." (Longer lengths may be required if you are working with a large console.) Do not connect the free ends of the red and black wires to your set at this time.

Next, you have to determine the point for external-video injection. Due to design differences, that point will vary from one set to another. The objective, in any case, is to get as close to the first video-amplifier as possible. At that point the signal-level within the set closely matches that of the signal that will be injected. The circuit impedence must be greater than 1000 ohms—otherwise the ability of the direct-video PC board to provide the appropriate video level and DC bias may be hampered. A high impedence is usually found at the base of a transistor or at the input of an integrated circuit. In general, when you choose the injection point, select it so that it will eliminate all (or most) of the set's bias networks when the BYPASS switch is thrown to its EXTERNAL position. Doing that will leave only the video signal and the DC bias from the direct-video board at the injection point. Mark your injection point on your own circuit diagram, and locate and mark it in your set.

Once the video-injection point has been determined, you'll have to determine whether positive or negative video is required. (Positive video means that the video-information signal is positive with respect to ground, and the sync signal negative; the opposite is true for negative video.) If you are unable to determine which type of signal your set needs at the injection point, assume for the moment that it's positive video. To select a positive-video output, connect pads "H" and "J" on the PC board with a jumper. For negative video, connect pads "G" and "H."

The final injection-point to be located is the one for external audio. The simplest place to inject the audio is usually at the high side of the volume control. However, some sets—as was the case with our Samsung—use an IC to control the volume level. In such sets the audio should be injected at a point after the detector de-emphasis network, and the level controlled through R32 on the PC board.

Some sets may require that you feed the driver stage directly. In that type of installation, the DC bias to the audio power-stage must be maintained. That can be done easily with a resistor network like

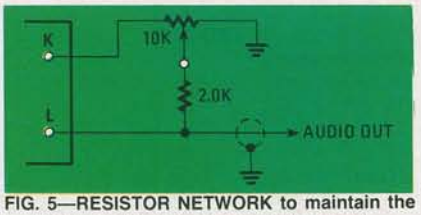


FIG. 5—RESISTOR NETWORK to maintain the DC bias to your set's audio power-stage.

the one shown in Fig. 5.

Having selected the injection point for your set, mark it on your circuit diagram and make sure you know where it is in the set.

Installation

Find a convenient place inside your set to mount the PC board, and drill the appropriate mounting holes. Figure 6 shows how the board was mounted in our Samsung. Place as much distance as is practical between the PC board and the flyback transformer to avoid any possibility of interference. Do not mount the PC board at this time, though.

Next, mount the audio and video input-jacks. Install them in a convenient location either on the back panel or side of the set. The jacks should be as close as possible to the PC board. Make sure that the video-input jack is mounted on an insulated surface (preferably plastic) if you are converting a hot-chassis type set. In our installation, we used a standard ¼-inch phono jack requiring a ⅜-inch hole, but BNC- or UHF-type connectors can also be used, as long as they are mounted on an insulated surface.

The miniature DPDT BYPASS switch, S1, should be mounted as close to the input jacks as possible. That switch will allow you to select either the RECEIVE or EXTERNAL mode. Once again, if you are converting a hot-chassis set, make sure that you mount the switch on an insulated surface.

You can now proceed with the wiring phase of the installation. Earlier, you determined the power source for the output section of the PC board and inserted an R36 of the appropriate value. Now, you must consider the power source for the input section of the PC board. If you are converting a set which is already transformer-isolated from the power line (as opposed to a hot-chassis set), the input portion of the direct-video board can use the same power source as the output section. In that case, take a piece of insulated

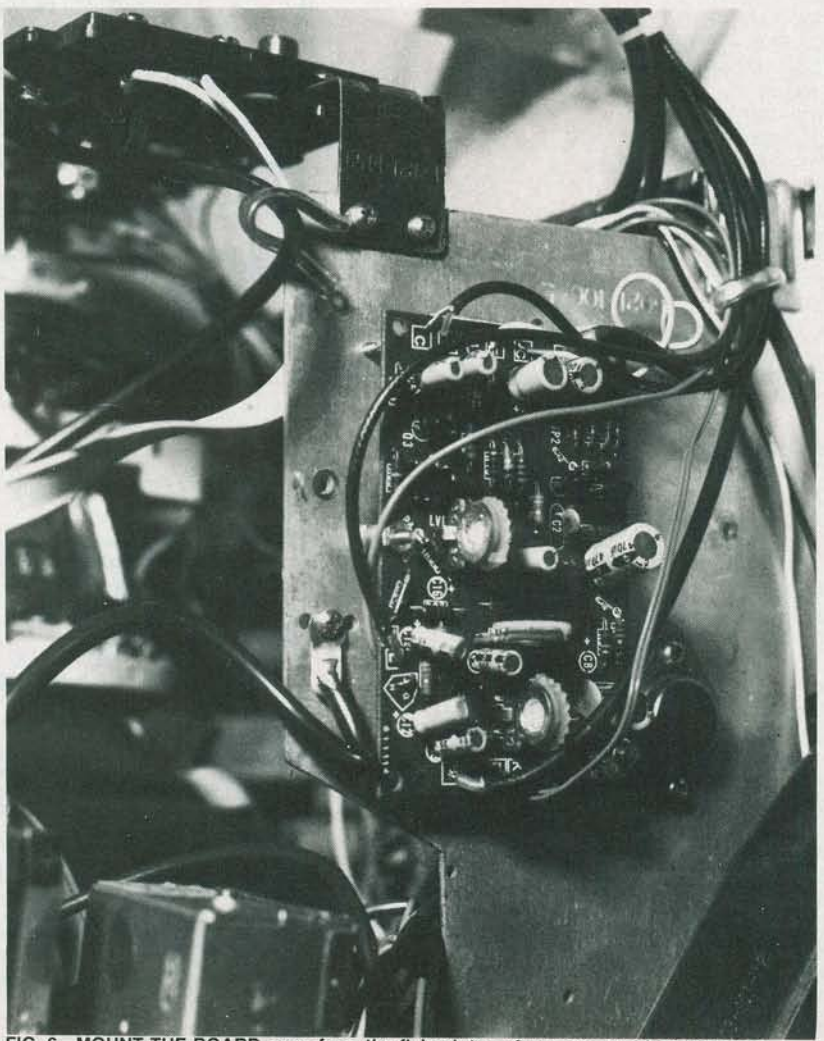


FIG. 6—MOUNT THE BOARD away from the flyback transformer to avoid interference.

wire and connect pads "C" and "F" which are the input common and outout common respectively. Use a second piece of insulated wire to connect pad "E" with the pad at TP6. Remember, those connections should be made only if the set you are converting is transformer isolated.

If the set you are converting is *not* transformer isolated, but is a hot-chassis type, then the power for the input section can be obtained from the flyback transformer. That will involve work in the high-voltage section of the set. Any time you are working in that area, be sure to unplug the set for safety. (*It would be a good idea to have the set unplugged* anytime *you're working inside it*—Editor.) As a further precaution, discharge the power supply. That is done by connecting one end of a wire to the chassis of the set and then carefully slipping the other end under the rubber high-voltage cap on the picture tube itself. Don't forget to remove the wire afterward.

Take a 6-foot length of (white) insulated single-conductor wire and fold it in half. Slip one end of the wire through the ferrite core of the flyback transformer so that there are two equal lengths on both sides of the core. Then take one of the ends of the wire and loop it twice around the ferrite core so that you end up with approximately 2½ turns around the core. (For console sets with screens larger than 19 inches you may require only 1½–2 turns.) Twist the wires together for their entire length and connect them to the direct-video board at pads "E" and "C." Figure 7 shows the windings around the core of the flyback in the Samsung set that we converted.

The next step is to determine whether there is a sufficient number of turns around the core of the flyback, and whether the wires to the board are phased properly. During the following test make sure that the PC board is clear of the set, to prevent any accidental shorts. Apply power to the set and turn it on. Indicator LED1 should light. If it does not, unplug the set and interchange the wires at pads "E" and "C." If the LED still doesn't light, unplug the set and add an additional ½–1 turn around the core of the flyback. If the LED still doesn't light, unplug the set again and interchange the wires on pads "E" and "C" so they're back in their original positions. (If you have an oscilloscope at your disposal, connect the leads from the windings so that the flyback pulse is positive with respect to ground.) If the LED *still* doesn't light, measure the voltage at TP-1. It should be positive with respect to ground. Increase or decrease the number of turns until the voltage at TP-1 reaches a value between 12 and 15 volts DC. The LED should light when the voltage exceeds 11-volts DC.

In the event that you can't get at the ferrite core of the flyback transformer, you will have to add a step-down transformer (120 volts:12 volts) or use a commercially available portable 12-volt DC power-adapter so that the input section can be powered directly from the AC line.

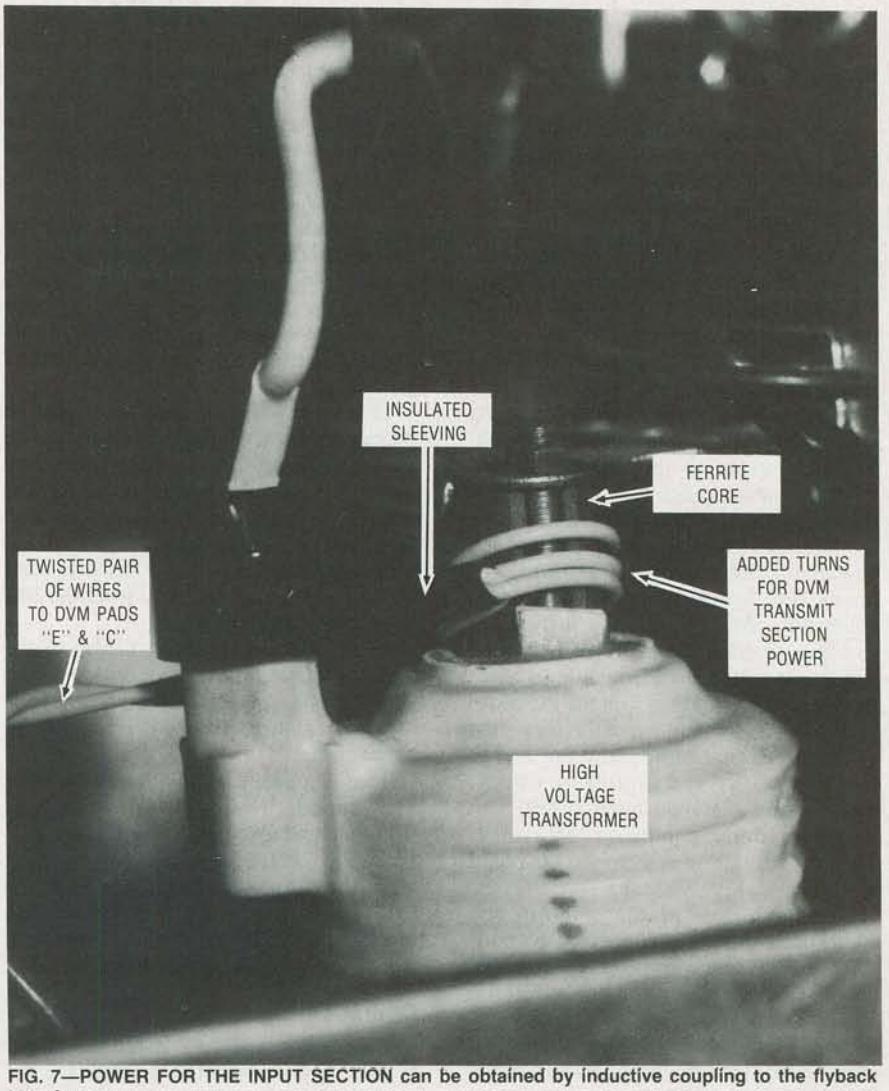


FIG. 7—POWER FOR THE INPUT SECTION can be obtained by inductive coupling to the flyback transformer.

Using Fig. 8 as a wiring guide, you can now start the final phase of the installation. First, cut two equal lengths of video cable (RG-59/U) long enough to reach from the video injection-point to S1. We'll refer to that as the DEMOD/RETURN cable pair. Label and set those cables aside momentarily. Next, cut a length of video cable that will reach from the S1 to the video output of the PC board at pads "B" and "F." We shall refer to it as the "B" cable. Label it accordingly. Cut an-

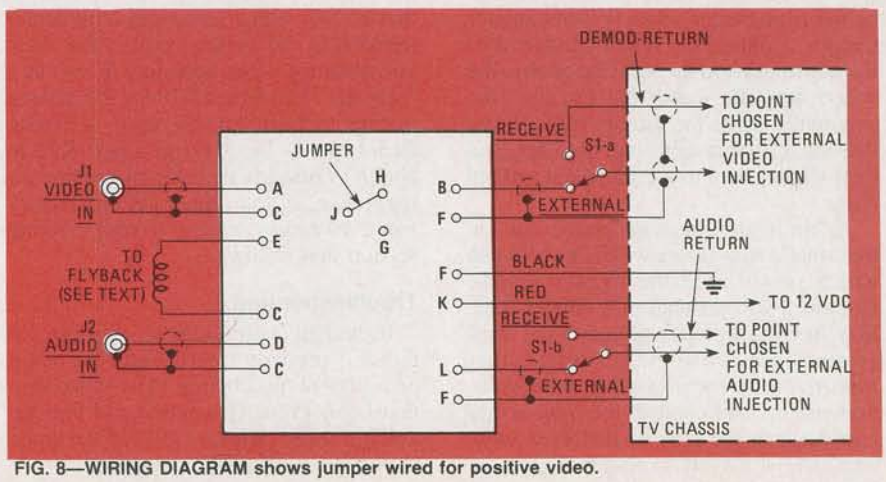


FIG. 8—WIRING DIAGRAM shows jumper wired for positive video.

other length of cable that will reach from the VIDEO-IN connector J1 to pad "A" on the PC board and label it as the "A" cable.

Strip one end of the "A" and "B" cables, making sure that you have a sufficient length of outer conductor (shield) unraveled. Then connect those ends to the PC board as shown in Fig. 8. Make sure that the center conductors of the cables are connected to the correct pads ("A" to "A" and "B" to "B"). Do not connect the other ends of the cables yet.

Prepare the audio cables next. Cut a length of *two-conductor* shielded cable long enough to reach from the BYPASS switch (S1) to the audio-injection point. We shall refer to this as the AUDIO-RETURN cable. Label it and set it aside momentarily. Now cut a length of *single-conductor* shielded audio cable long enough to reach from pads "D" and "C" on the PC board to the AUDIO-IN (J1) connector. We will refer to that as the AUDIO-IN cable. Cut another length of single-conductor shielded cable to reach from pads "L" and "F" on the PC board to the BYPASS switch; we will refer to that as the AUDIO-OUT cable. Strip one end of the AUDIO-OUT and AUDIO-IN cables, making sure that you have a sufficient length of outer conductor unraveled. Then connect those ends to the PC board as shown in Fig. 8. Make sure that the center conductors of the audio-in and audio-out cables are connected to pads "D" and "L," respectively. Do not connect the other ends of the cables yet.

You can now mount the PC board permanently using 4-40 machine screws and nuts. Use ¼-inch fiber spacers to insulate the board from the TV chassis, and make sure that the PC-board foil doesn't touch any metal surface. Once you have secured the PC board, strip one end of each of the DEMOD/RETURN cables you set aside earlier. At the external-video injection point remove a small portion of the copper trace that connects the two points between which you wish to insert the BYPASS switch. (Instead of breaking a trace you may have to cut a wire; it depends on your TV set.) Connect the center conductor of the demodulator cable to the side that comes from the set's own IF/demodulator circuits. Connect the center conductor of the return cable to the side that goes to the video amplifiers and the circuits that eventually drive the picture tube. Twist the shields of that cable pair together, and then solder them to a convenient ground point.

At the audio-injection point, cut the trace that connects the two points between which you'll insert the BYPASS switch. (Again, a wire instead of a copper trace may have to be cut.) Connect the *dark* center conductor to the side that comes from the set's own sound IF demodulation circuits and connect the *light* center conductor to the circuits that eventually terminate at the set's speaker. Route the AUDIO-RETURN cable and the DEMOD-RETURN cables through the set and connect them to S1 as shown in Fig. 8. Now strip the free end of the "B" cable and connect it to the switch. Next, strip the free end of cable "A" and connect it to the video-input connector. Then, strip the free end of the audio-out cable and connect it to the BYPASS switch; also strip the free end of the audio-in cable and connect it to the audio-input connector. Finally, connect the red wire from the PC board to the voltage-source point you selected earlier, and connect the black wire to chassis ground.

If your installlation used the inductive pickup from the flyback transformer, be sure to route the wires to the board so they avoid, as much as is practical, the RF and low-level video demodulator circuits; that will minimize interference. Also, make sure that the pair of wires is twisted its full length—all the way from the flyback to the PC board.

Connect the appropriate cables to the video- and audio-input connectors. Make sure that you connect the center conductor of each cable to the center pin of the connector.

That completes installation of the conversion board. Check all your connections, and also make sure that the PC-board foil pattern is not touching any metal surface. Finally, make sure that the input connectors and BYPASS switch are insulated from the TV chassis, especially if you are converting a hot-chassis set.

Operation

Having checked your installation thoroughly, apply power to the set. Place the BYPASS switch in position for normal TV operation. If the set does not work properly, you have wired something incorrectly (most likely the switch). Retrace your steps through the installation instructions.

Once the set operates normally as a receiver, use a voltmeter to measure the DC-bias voltage at the center terminal of the BYPASS switch with respect to chassis. Then apply a standard video signal to the VIDEO IN jack. Set the BYPASS switch to the EXTERNAL position. Adjust R28 so that the DC voltage measured at the center terminal of the switch matches the value you obtained when operating the set as a receiver. Then adjust R18 for the desired picture contrast. Finally, apply a tone to the AUDIO IN jack J1 and adjust R32 to obtain a comfortable listening (or operating) range. If you cannot get satisfactory video or audio, see the troubleshooting section that follows.

Troubleshooting

If the LED will not light, check to see that it is properly inserted into the board and is not reverse biased. Also make sure that D3 is properly inserted and that the voltage at the cathode (TP1) of the diode is positive with respect to ground.

If you have no video, or if the picture quality is poor, the problem may be due to an incorrect DC bias (that can result in complete picture loss or heavy picture tearing). To correct the problem, adjust R28 for the appropriate bias level.

If you have no video in either mode (RECEIVE or EXTERNAL), the problem is probably a mis-wired BYPASS switch. Check the wiring, referring to Fig. 8.

A streaky, clipped, or washed-out picture may be caused by too high a video level. Adjust R18. Sometimes a misadjusted bias level (R28) can cause similar problems.

Interference may be due to ripple from the low-voltage source used to power the receiver section of the direct-video board. Changing the board to operate from a DC source in the 105–165-volt range usually clears up the problem. Also check the shields of the cables for proper connections. Another source for possible interference is the route selected for the twisted pair of wires that runs from the PC board to the inductive loop on the core of the flyback. It is important that the pair be twisted over its entire length, and that the bundle be kept away from the demodulator, IF, and RF circuits.

TABLE 2
Test Point Voltages

	VDC Min.	VDC Max	
TP1	11.0	15.0	Ref. "C"
TP2	5.0	8.0	
TP3	5.0	7.5	
TP4	0.2	0.35	Ref. "F"
TP5	5.0	7.0	
TP6	10.0	12.5	
B	Adjustable		
G	2.2	4.0	
J	7.0	9.0	

Low audio output can be caused by your set requiring a higher signal level at the audio-injection point than is currently being supplied. Install C16 to boost the board's audio output.

Should your set not display external video and you have wired everything correctly, check the direct-video board for failure. Refer to Table 2 and measure the voltages at the appropriate test points. Note that the voltages at test points TP1, TP2, and TP3 are measured with respect to pad "C." The voltages at all other test points are measured with respect to chassis common or pad "F." Check to make sure you have not installed the transistors or optoisolators incorrectly.

After you've made any adjustments necessary, replace the rear cover of the set. Your newly converted set is now ready for use. Rest easy and let your eyes relax. **R-E**