An Audio/Video Distribution Amplifier

This device eliminates signal-loss problems usually encountered when trying to interconnect a TV receiver, one or more VCRs and similar products into a single video entertainment system

By Jack Cunkelman

The variety of video equipment used in home-entertainment systems has multiplied amazingly over the past ten years. People now have several VCRs, video cameras, laser-disc players, satellite TV receivers, cable TV converters, and computer video monitors, for example, as well as stereo hi-fi components. All of these sources are usually separate units that must be interconnected to make up a "system." How to do this without loss of any of the performance quality designed into each unit, which can cause a "grainy" picture or severe reduction of audio high frequencies, can be a real problem. A functional solution is building (and using) the Audio/Video Distribution Amplifier to be described.

The A/V Amplifier is a relatively simple, low-cost homebrew project that counters signal losses that can deteriorate reception. Additionally, it offers an orderly way to interconnect a bevy of video products. It provides three independent video and three independent audio outputs (all isolated from each other) and features *stereo* sound for each of its audio outputs so that it's ready to accommodate stereo TV broadcasts if you can receive them with the MTS stereo incorporated into newer TV receivers. If you need more audio and video lines than provided in the basic unit, you can build more Distribution Amplifiers as needed, just as inexpensively.

Interconnections

The most common interconnection method for the various devices used in home video entertainment systems has been to distribute the signal as r-f on a coaxial cable. The r-f signal contains both video and audio information that is modulated on an r-f carrier for delivery to the antenna terminals on a typical TV receiver, which is tuned to the particular channel designated for its reception. Modula-

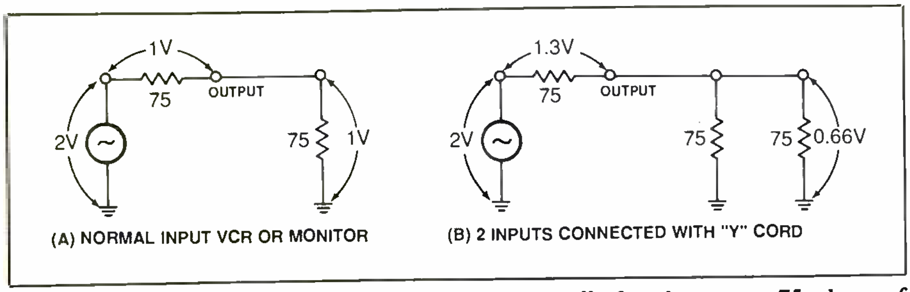


Fig. 1. Outputs from video equipment are normally 2 volts across 75 ohms of impedance. Matching such outputs with the same impedance causes a 1-volt signal to be delivered to the equipment being driven, as in the upper illustration. If two devices, both with an input impedance of 75 ohms were to be connected in parallel (as would be done with a Y connector) across the 75-ohm source impedance, each would receive only 0.66 volt of the signal, as in the lower illustration.

tion is accomplished by the same process TV stations use to send their program audio and video signals to you.

A VCR also applies this modulation process to the audio and video signals from tape. This combined r-f signal usually exits the VCR at a frequency that can be tuned to the TV receiver by setting its channel selector to either channel 3 or channel 4. (You select which channel you want the signal to be on by setting a switch in the VCR). The TV receiver, a second VCR or whatever other device is receiving the signal demodulates the r-f signal to extract the original audio and video information so it can deal with them separately.

The r-f/coax cable method of interconnection is the most straightforward and popular in current use. However, it is not necessarily the best. In fact, in a typical home installation that has more than three video devices that have to be connected to form a system, it may not even be practical.

Every time the audio and video signals are combined by a modulator and are then demodulated, a little of the signal quality is lost. If the signals are modulated and demodulated several times, deterioration becomes noticeable. Consider that a TV program recorded from a cable TV hookup has undergone the modulation/demodulation process three times before you finally view it. If you were to compare the original with the taped program, you would observe an obvious degradation in the taped version.

If you were dealing with a stereo audio signal, you would discover that one of the two audio channels is missing because the standard modulation process can deal with only one channel of audio. Thus, it is desirable to manipulate and distribute the audio and video signals separately. As consumers have become more quality-conscious, equipment de-

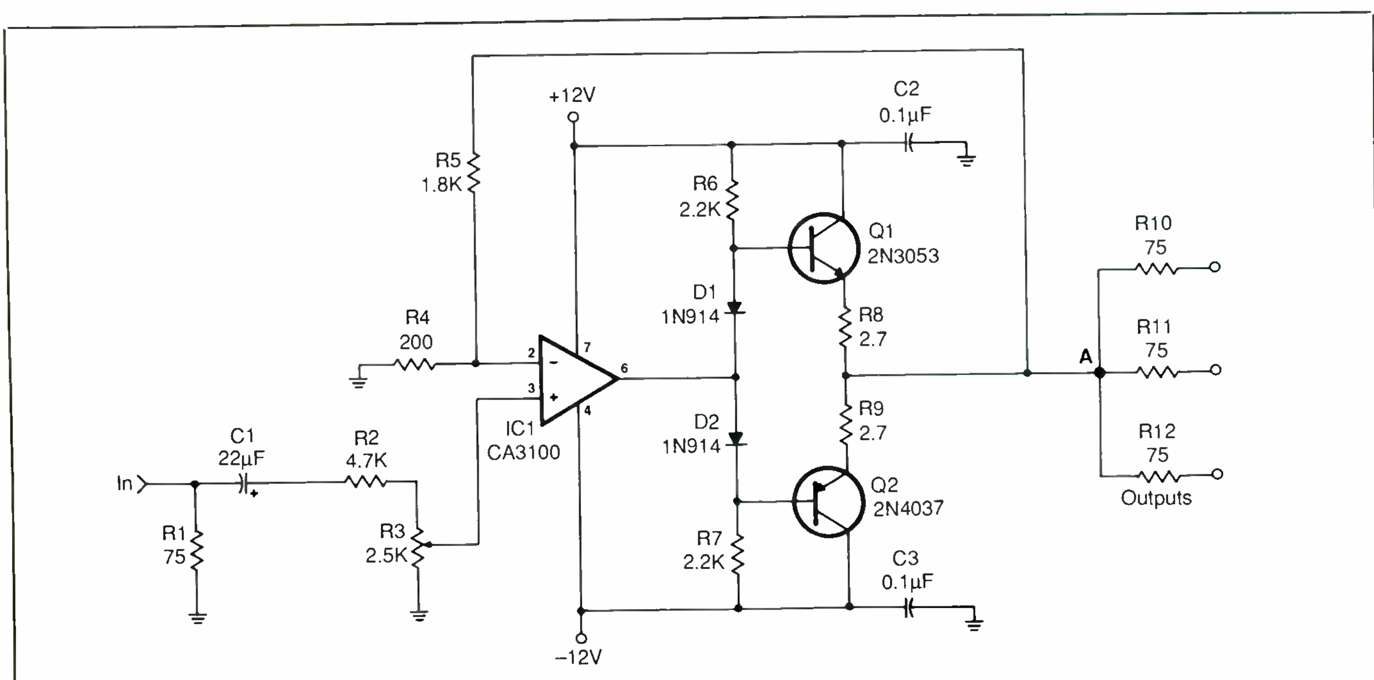


Fig. 2. The video portion of the Distribution amplifier.

signers have devised equipment that allows them to deal with audio and video signals separately.

Most home VCRs have separate video and audio input and output jacks, as well as the usual cable connector for the modulated r-f signal. The new generation of TV receiver/monitors now have audio and video inputs, as well as the usual r-f antenna terminals. Home video cameras also have individual audio and video outputs. The main problem, then, is in distribution of video signals to all of the devices that may be in a home video entertainment system.

The video output from a VCR, for example, consists of a 2-volt, 75-ohm signal (Fig. 1). The input of the receiving device (say, a TV monitor or another VCR) presents 75-ohm load to this signal. This is the terminating input. When both ends are connected, 1 volt of the 2-volt signal appears across the source termination and the remaining volt appears across the input termination of the destination device. If you were to connect two inputs to this one output, such as is done when you use a "Y" connector, the level across each input would drop to 0.6 volt. The result is a noticeable degradation in picture and/or sound quality.

Each receiving device requires its own separate feed because every input is terminated. Terminations are required to keep reflections off the interconnecting coaxial-cable line.

While audio distribution is not as critical in this respect, running separate isolated audio and video lines to each device is a good idea. Also, driving the audio interconnect lines from a low-impedance source allows you to use longer interconnect cables.

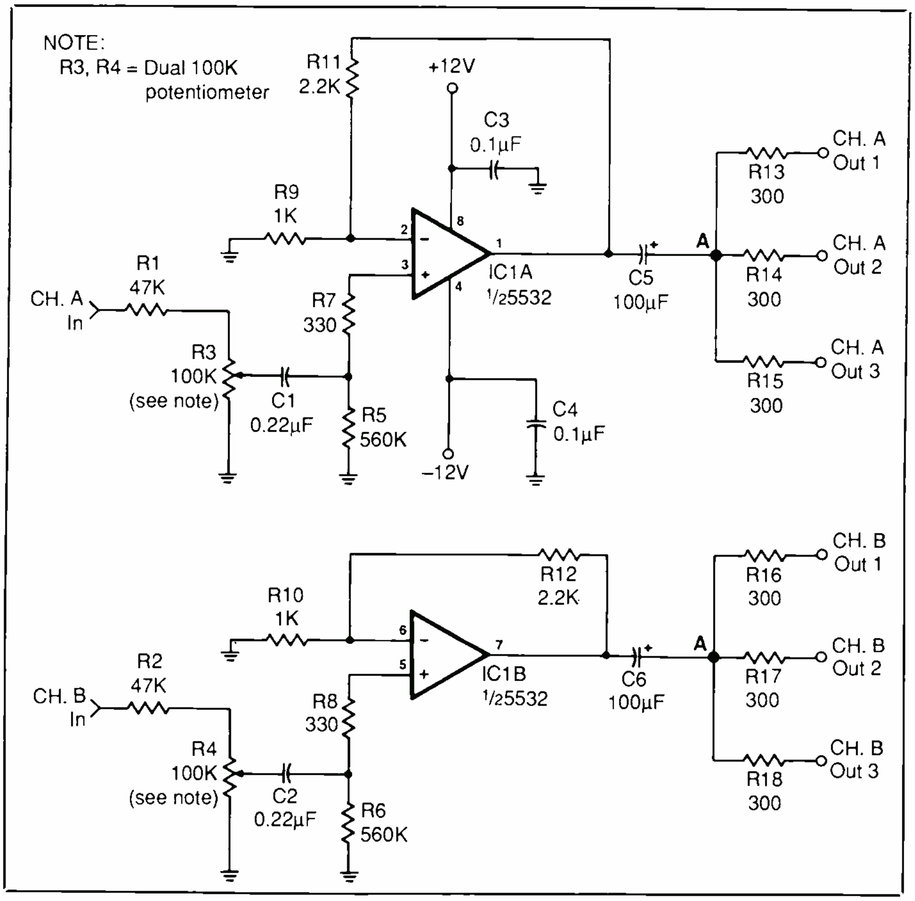


Fig. 3. The audio portion of the Distribution amplifier.

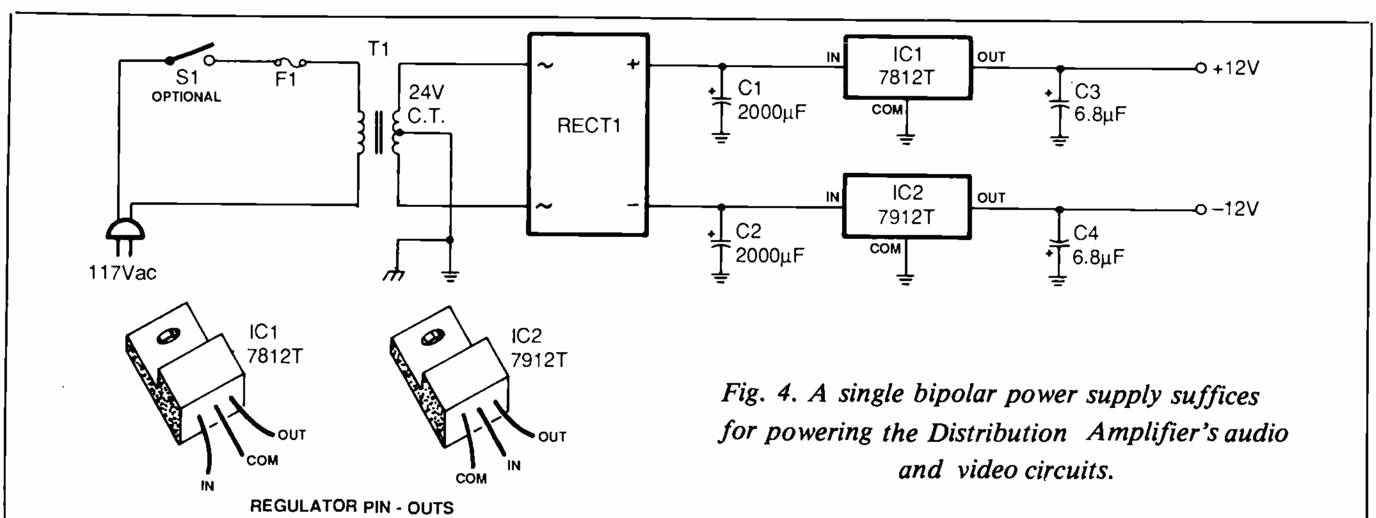


Fig. 4. A single bipolar power supply suffices for powering the Distribution Amplifier's audio and video circuits.

PARTS LIST

Video Amplifier
C1,C2—0.22-μF Mylar capacitor
C3,C4—0.1-μF disc capacitor
C5,C6—100-μF, 25-volt radial-lead electrolytic capacitor
IC1—5532 dual operational amplifier
All resistors ¼-watt, 5% tolerance carbon film
R1,R2—47,000 ohms
R5,R6—560,000 ohms
R7,R8—330 ohms
R9,R10—1,000 ohms
R11,R12—2,200 ohms
R13 thru R18—300 ohms
R3,R4—Dual 100,000-ohm, linear-taper potentiometer

Audio Amplifier
C1—22-μF, 16-volt radial-lead electrolytic capacitor
C2,C3—0.1-μF disc capacitor
D1,D2—1N914 diode
IC1—CA3100 BiMOS operational amplifier
Q1—2N3053 pnp transistor
Q2—2N4037 npn transistor
All resistors ¼-watt, 5% tolerance carbon film
R1,R10,R11,R12—75 ohms
R2—4,700 ohms
R4—200 ohms
R5—1,800 ohms
R6,R7—2,200 ohms
R8,R9—2.7 ohms
R3—2,500-ohm, linear-taper potentiometer

Power Supply & Chassis
C1,C2—2,200-μF, 25-volt axial-lead electrolytic capacitor
C3,C4—6.8-μF, 16-volt tantalum capacitor
F1—0.5-ampere slow-blow fuse
IC1—7812T +12-volt regulator
IC2—7912T −12-volt regulator
RECT1—100-volt, 2-ampere bridge rectifier
S1—Spst toggle or slide switch (optional)
T1—24-volt, 1-ampere center-tapped transformer
Misc.—Printed-circuit boards or perforated board and suitable soldering or Wire Wrap hardware; sockets for ICs in audio and video amplifiers; bayonet-type fuse holder or chassis-mount fuse block; 4-place phono-jack strip for video input and outputs (Radio Shack Cat. No. 274-322A or similar); 8-place phono-jack strip for audio inputs and outputs (Radio Shack Cat. No. 274-370 or similar); metal enclosure (Radio Shack Cat. No. 270-274A or similar 8¼"W × 6⅛"D × 3¹⁄₁₆"H box); ac line cord with plug; small-diameter coaxial or shielded cable; clip-on heat sinks for regulators in power supply (optional); insulated standoff post; pointer-type knobs for controls; labeling kit; clear spray acrylic (see text); ½" metal spacers (12); machine hardware; hookup wire; solder, etc.

Note: Etched, drilled and plated printed-circuit boards are available from Jack Cunkelman, P.O. Box 397, Milford, OH 45150: No. V11 video board for $7.00; No. A11 audio board for $7.00; No. PS11 power-supply board for $5.00. Add $1.00 P&H per order. Ohio residents, please add 6% state sales tax.

If you have audio and video jacks on your home-entertainment equipment (these are usually coaxial phono jacks like those used on audio equipment), you may want to utilize them and the Audio/Video Distribution Amplifier to be described to configure your system. The Distribution Amplifier's three video and three audio outputs (the latter with two stereo channels) should allow for maximum flexibility. The noticeable increase in audio and, especially, video performance will make building and using this project a worthwhile effort.

About the Circuit

Three separate circuits make up the Audio/Video Distribution Amplifier: the video, the audio and the power supply. The basic reason for this arrangement is that distribution amplifiers are designed to provide multiple isolated outputs of an input signal. By making the circuits separate, it is relatively easy to maintain isolation.

In any distribution amplifier, the signal at the output is at the same level as the input signal. The Audio/Video Distribution Amplifier described here takes this into account. It also features variable gain for those situations where there is too great or too little a signal level for optimum viewing and listening. Thus, it eliminates the need for an extra signal attenuator and/or booster.

Three amplifiers are provided: one video and two audio. The video portion of the circuit, shown in Fig. 2, utilizes an RCA CA3100 BiMOS operational amplifier *(IC1)*. This op amp has excellent high-frequency response and should not be substituted. Transistors *Q1* and *Q2* boost the output current from *IC1*. Feedback is provided by *R5* to give the circuit linearity and stability.

Circuit gain is determined by the ratio of *R4* to *R5*. The values of these resistors were chosen so that a 1-volt signal across input terminator *R1* produces a 2-volt signal at point A when *R3* is set to the middle of its rotation.

Because point A is a very-low impedance, resistors *R10*, *R11* and *R12* serve as the sending-end terminators to provide the 75-ohm output impedance required to drive the coaxial interconnecting cables. Since point A is an ideal (almost 0-ohm) voltage source, whatever occurs at the output side of any one of the sending-end terminating resistors has no effect on the output sides of the other two sending-end terminating resistors. Hence, each output is isolated from the others.

Bypass capacitors *C2* and *C3* are required to prevent oscillations. Nominal bandwidth of this amplifier is 10 MHz. So high-frequency oscillations could be a problem if these bypass capacitors were not used.

Shown in Fig. 3 is the audio portion of the Distribution Amplifier. This circuit is built around 5532 dual op amp *IC1*, which handles the two channels of audio in a single integrated-circuit package. Since both channels operate identically, we will discuss only one.

Op amp *IC1* is a low-noise device that is optimized for audio applications. The input impedance of this Distribution amplifier is 47,000 ohms, which is set by *R1*. The gain of *IC1* is set by the ratio of *R11* to *R9*. With GAIN control *R3* set at its middle of rotation, the signal level at point A is the same as the input signal's level. This is different from the video Distribution Amplifier because the impedances of the loads connected to the outputs (the inputs of a VCR, for example) are usually 10,000 ohms or greater so that there is no drop across 300-ohm output termination resistors *R13*, *R14* and *R15*. (Note: *R3* and *R4* is a ganged dual-potentiometer, which allows the gain of both audio channels to be adjusted simultaneously.)

The low output impedance of the Distribution Amplifier allows you to make long runs to other equipment with no loss of high frequencies. Note once again that the +12- and −12-volt power buses are bypassed by *C3* and *C4*, respectively, to prevent unwanted oscillations.

A single bipolar power supply suffices for both audio and video portions of the Distribution Amplifier. The circuit for this power supply is shown in Fig. 4. After 117-volt ac line power is stepped down by *T1* to 24 volts ac, it is rectified to pulsating dc by bridge rectifier *RECT1*. The 24-volt pulsating dc output from

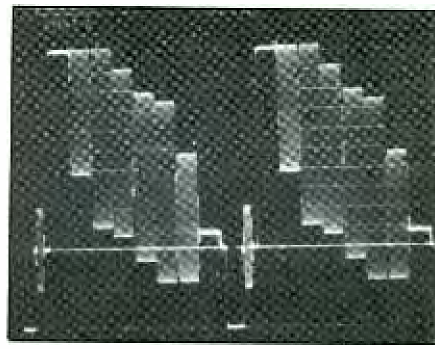
TECHNICAL SPECIFICATIONS

Audio Amplifier

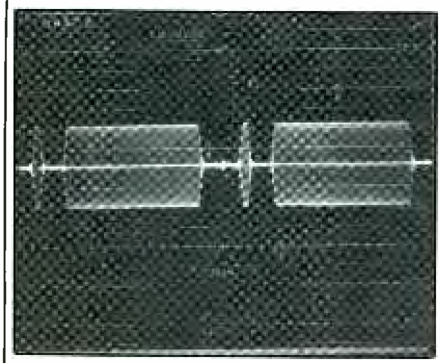
Distortion (at −4 dBV)........ < 0.02%
Signal-to-noise ratio......... >−70 dBV
Frequency response
...........20 Hz to 30 kHz, ±0.1 dB
Clipping point................ +9 dBV

Video Amplifier

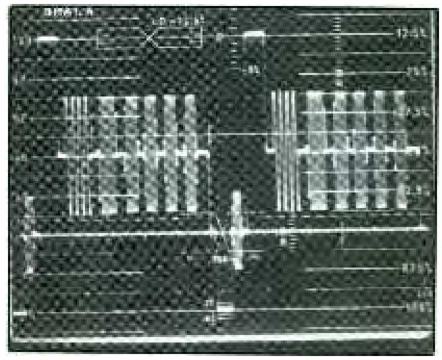
Differential phase.......... <0.5 degree
Differential gain............. See photo



VIDEO COLOR-BAR RESPONSE



VIDEO DIFFERENTIAL GAIN



VIDEO MULTIBURST RESPONSE

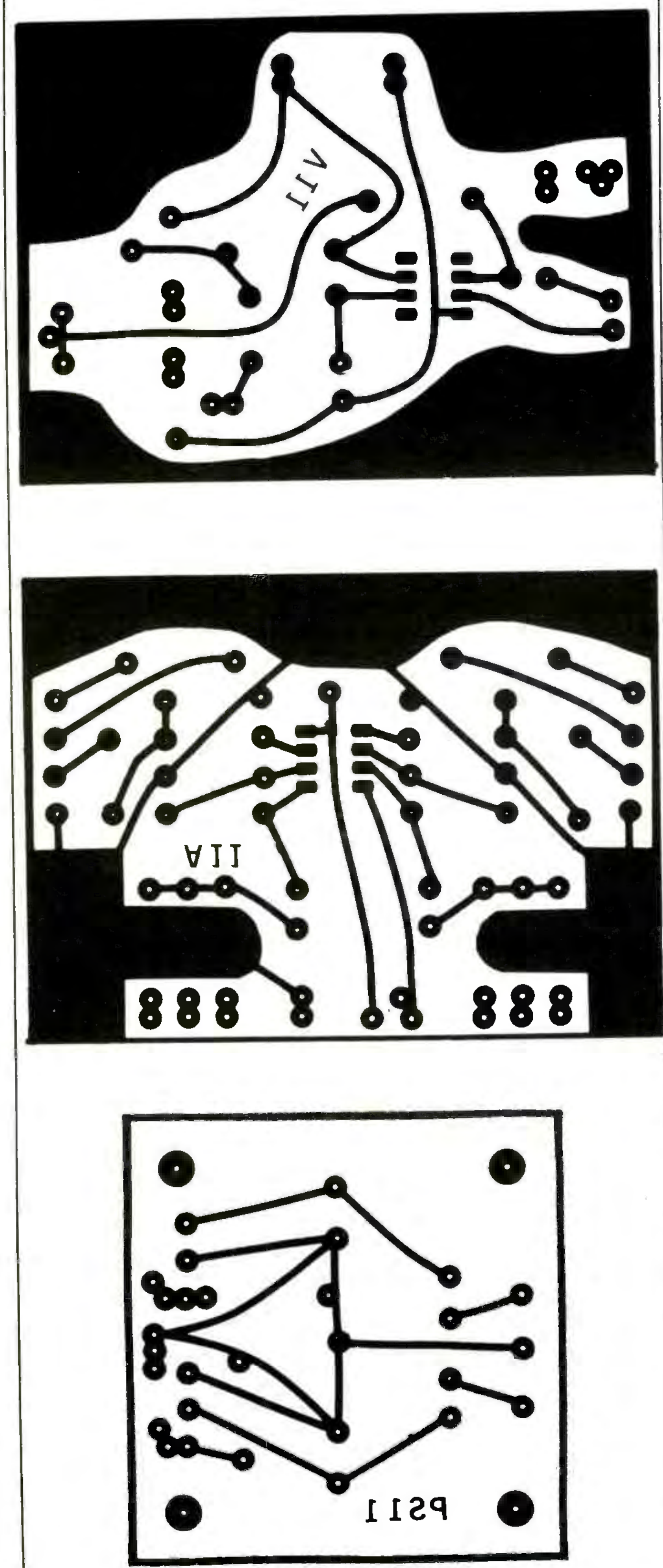
RECT1 is then filtered to clean dc by *C1* and *C2* and is regulated at +12 and −12 volts dc by *IC1* and *IC2*, respectively. Capacitors *C3* and *C4* serve as bypasses that prevent unwanted oscillations. POWER switch *S1* is an option.

Construction

Since the circuitry for all three sections of the Audio/Video Distribution Amplifier is fairly simple, any of a number of traditional methods of wiring can be used to build the project, though printed-circuit wiring is preferable. If you wish, you can fabricate your own pc boards, using the actual-size etching-and-drilling artwork in Fig. 5. Alternatively, you can purchase ready-to-wire boards from the source given in the Note at the end of the Parts List.

The audio and video boards are both the same size, measuring 3½″ × 2½″, while the power-supply board measures 2½″-square. Whatever wiring technique you use, the circuits can be built on boards of these dimensions. All wiring to and from these boards should be done neatly to avoid unwanted oscillations and crosstalk. Also, use sockets for the ICs on the video and audio boards, but not on the power-supply board.

Wire each board exactly as shown in Fig. 6, working on only one board at a time so that you do not make any component errors. Install only the sockets for the ICs on the audio and video boards—*not* the ICs themselves; these will be installed after you make voltage checks. Install and solder into place the resistors, followed by the capacitors (observe polarity with the electrolytics). When wiring the video board, make sure you install the transistors in the proper locations and that you observe proper basing. Also, make certain that the diodes are properly oriented.



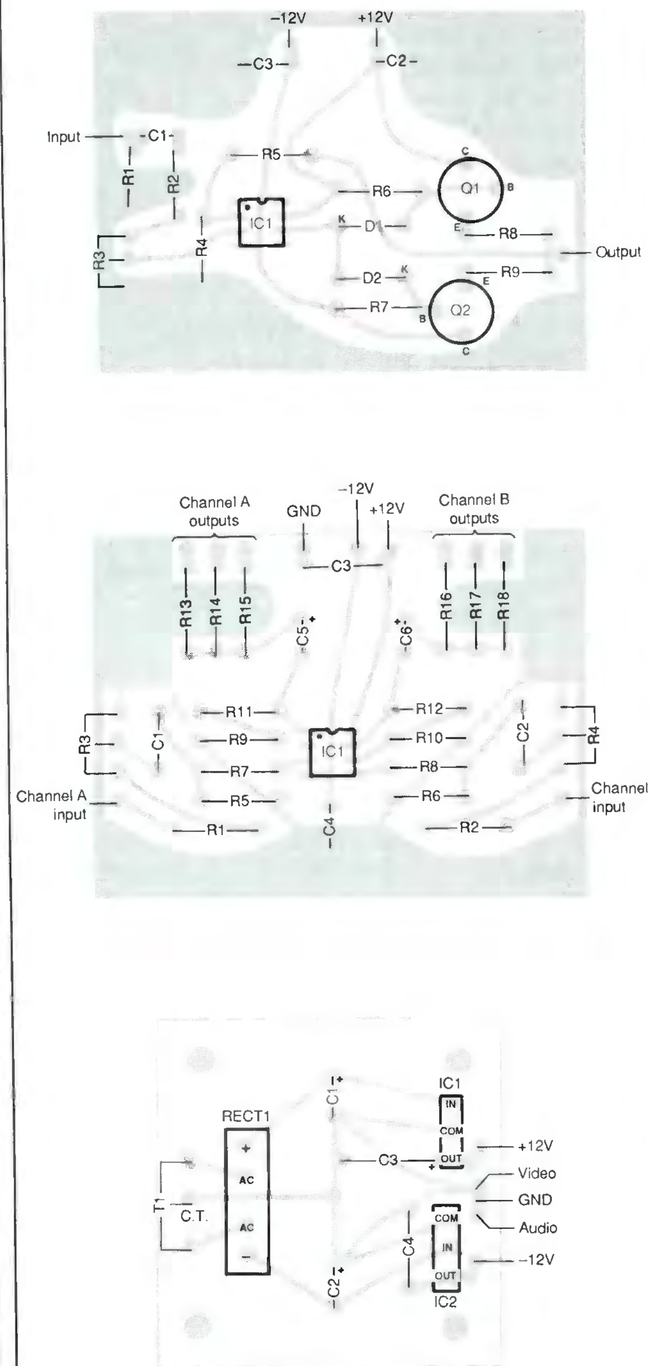


Fig. 5. The actual-size etching-and-drilling guides (left) to use if you plan on fabricating your own pc boards.

Fig. 6. Wiring guides (above) for the pc boards. These guides are also used to lay out circuit assemblies wired point-to-point with solder or Wire Wrap hardware.

Similarly, make sure the diodes are properly oriented, and make sure the regulators are installed in the appropriate locations, also properly based, on the power-supply board. Ditto for the bridge rectifier.

If you are using perforated board, arrange the components on the boards in the same patterns and orientations as for the pc boards. Use #22 solid hookup wire to interconnect all components. Route the wiring as directly and make it as short as possible.

Referring to Fig. 7, place the circuit-board assemblies inside the enclosure, in the locations shown and determine how long the wires that interconnect them must be. Make a note of the lengths needed and where they are to be installed. Remove the circuit-board assemblies from the enclosure. Prepare the wire lengths needed. Then install and solder them into place. Note that there are two +12-volt and two −12-volt output pads on the power-supply board, one set each for the audio and video amplifier circuits.

At this point, there should be no wires in the holes for the GAIN controls or the inputs to and outputs from the audio and video boards. There should also be no wires in the 24-volt ac and center-tap (*T1* secondary) holes in the power-supply circuit board.

Prepare 13 8″ lengths of hookup wire by removing ¼″ of insulation from one end of each. Plug the prepared ends of these wires into the output and control holes in the audio and video boards and solder the connections. When you are done, there should be 10 wires attached to the audio board and 3 wires attached to the video board.

Prepare both ends of three 7½″ lengths of small-diameter coaxial or shielded cable. To do this, remove 1″ of the outer plastic jacket, separate the shield back to the cut line, and strip ¼″ of insulation from the center conductor at both ends of the cables.

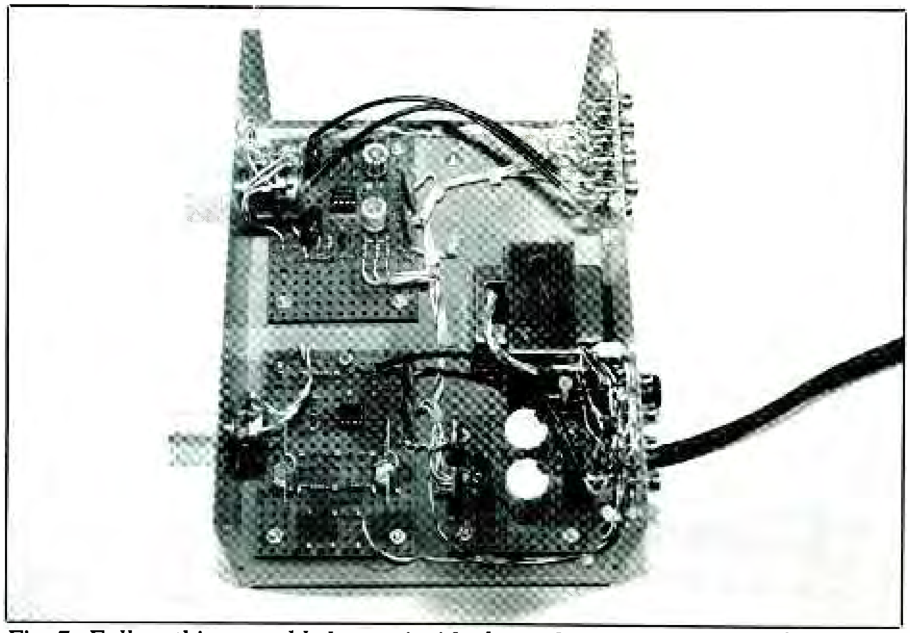


Fig. 7. Follow this assembly layout inside the enclosure to avoid interference between the power transformer and the audio and video circuits.

Tightly twist together the shield wires and sparingly tin with solder. Do the same for the fine wires in the inner conductors. Plug one end of each of the prepared cables into the "input" holes on the audio and video boards (shields to ground or common). Solder the connections in all six locations. The other ends of these cables and the previously installed wires will be connected later.

Now remove ¼″ of insulation from both ends of a 1½″ length of hookup wire. Connect and solder one end to a No. 6 solder lug. Plug the other end into the center-tap (C.T.) hole in the power-supply board and solder it into place.

When you are finished wiring the boards, carefully inspect them for poorly soldered connections and solder bridges, the latter especially between the closely spaced IC pads. If you suspect a connection, reflow the solder on it and, if necessary, add more solder.

Flip over the boards and double check all components for proper values, locations and orientations. Clip small heat sinks onto the cases of *Q1* and *Q2* on the video board. The regulators on the power-supply board (*IC1* and *IC2*) run warm when the project is operating but do not require heat sinking. If you feel more comfortable with heat sinks, however, you can bolt onto the regulators small ones.

The enclosure for the project is not critical. Only two requirements must be met by it. One is that it must be large enough to comfortably accommodate the three circuit-board assemblies, power transformer, POWER switch (if used), GAIN controls, fuse holder and the input and output jack assemblies. The other is that it must be metal—*not* plastic—so that it fully shields the circuitry from electrical noise.

Machine the enclosure as needed, basing your layout on that shown in Fig. 7. The arrangement shown assures that there will be no interference between the power transformer and the audio and video circuit boards. Use the boards and power transformer themselves as templates

(Continued on page 86)

for marking their mounting hole locations on the floor of the enclosure. Drill holes large enough to accommodate No. 6 machine screws for the transformer and No. 4 machine screws for the circuit-board assemblies at the marked locations.

Next, cut the slots for the input and output phono-jack assemblies in the enclosure's rear wall. The easiest way to do this is with a nibbling tool. If you do not have such a tool, drill a number of interconnected holes around the perimeter of the slots and use a file to square up the slots. Drill the line-cord entry hole (make it large enough for a small rubber grommet) and the bayonet-type fuse holder, as shown in Fig. 8. (If you prefer, you can mount an inexpensive chassis-mount fuse block inside the enclosure to the left of the power transformer and eliminate having to drill the large hole required for a bayonet fuse holder.)

Prepare the front panel as follows. First draw a light pencil line parallel to the bottom of the front panel 1⅛″ to 1¼″ up. Then measure about 2″ in from both sides and strike short lines at these points across the first. These two points locate the centers of the holes that must be drilled for the GAIN controls. By mounting the controls in the holes drilled at these points, they will not interfere with the audio and video boards when the project is assembled.

Deburr all holes. Then use a dry-transfer lettering kit or a tape labeler to label the AUDIO GAIN and VIDEO GAIN controls and AUDIO and VIDEO INPUTS and OUTPUTS. If you use a dry-transfer lettering kit, protect the labels by spraying two or three *light* coats of clear acrylic over the front and rear panels. Wait for each coat to dry before spraying on the next.

Now mount all elements in place, starting with the power transformer. Before mounting the transformer, however, plug its secondary leads into the T1 Secondary holes in the power-supply board, solder into place and trim the excess lead lengths. Use 4-40 × ¾″ machine screws for mounting the circuit boards and 6-32 × ¼″ or ⅜″ machine screws for the power transformer and rear-panel jack assemblies. Use 6-32 or 4-40 machine nuts and No. 6 or No. 4 lockwashers to secure all hardware, except screw an insulated standoff post onto the left screw end (viewed from the front of the enclosure) of the video jack assembly. Sandwich the No. 6 solder lug attached to the free end of the wire coming from the power-supply board between the spacer and floor of the enclosure at one corner of the power-supply board to ground it to the chassis.

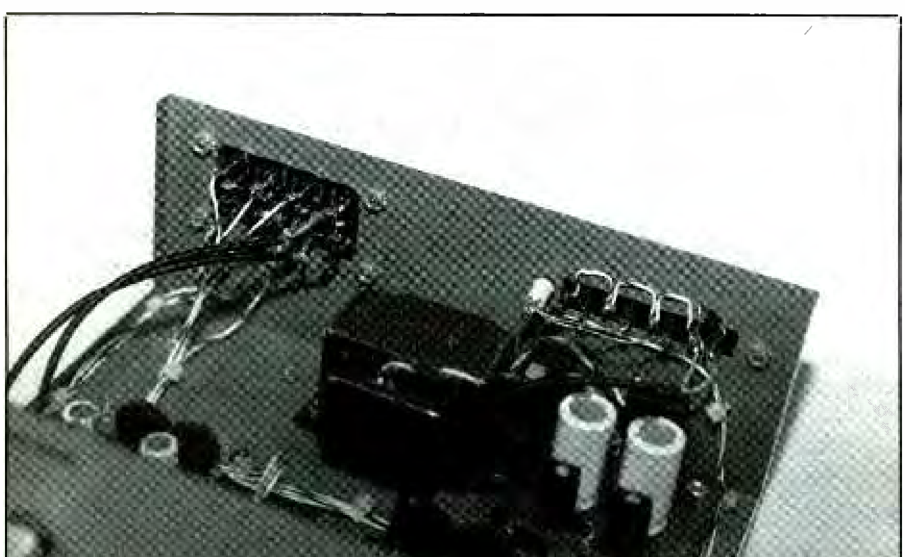


Fig. 8. Rear panel component mounting and wiring details.

Line the appropriate hole in the rear panel with a rubber grommet. Then trim ⅜″ of insulation from both conductors at the free end of the ac line cord. Tightly twist together the fine wires in both conductors and sparingly tin with solder. Pass this end of the line cord through the rubber grommet into the enclosure and tie a knot about 4″ from the prepared end inside the enclosure.

Mount the controls (and POWER switch, if you have decided to include it) on the front panel in their respective holes and the fuse holder on the rear panel (unless you have decided to use the internal fuse block). Now, referring to both the schematic diagrams and the wiring guides, interconnect all elements as shown.

One conductor of the ac line cord connects to one of the lugs on the fuse holder. Then one primary lead of the power transformer connects to one lug of the POWER switch, while a length of hookup wire interconnects the remaining lugs on both the POWER switch and fuse holder. When this has been done, wrap electrical tape over the contacts of the fuse holder and POWER switch's lugs to insulate the ac line from the rest of the circuit. Alternatively, you can slip over the whole rear portion of the fuse holder a 2″ length of large-diameter heat-shrinkable tubing and shrink it into place to insulate this assembly.

You have two choices for wiring the other line cord to the other primary lead of the power transformer. The simpler method is to twist together the remaining ac line cord conductor and remaining primary lead of the transformer and screw onto the connection a wire nut. The alternative is to slip a 1″ length of small-diameter heat-shrinkable tubing over one wire, twist together and solder the wires and shrink the tubing tightly over the connection so that it is fully insulated.

Referring back to Fig. 6, wire the GAIN controls to their respective boards, using the wires previously installed. Trim the wires to as short as needed before connecting and soldering them to the lugs of the controls.

One lead of resistors *R10*, *R11* and *R12* for the video circuit wires to the signal (center or "hot") lug of each of the VIDEO OUTPUT jacks. The other leads of these resistors tie together to form a common junction with the output wire from the video board. To make this connection, trim the resistor leads to length and wrap them around the post on the insulated standoff. Trim the output wire from the video board to length before wrapping it, too, around the post and solder the connection.

Connect and solder the free ends of the coaxial cables previously installed on the audio and video boards to the appropriate lugs of the remaining input and output connectors on the rear panel. Remember, the center conductors of these cables go to the signal lugs of the jacks, the shields to the ground lugs. Finally, interconnect all ground lugs on both jack assemblies, including the ground lugs to which the coaxial cables are connected. You can use bare solid wire to accomplish this, but make certain that no portion of the wire contacts the signal lugs of the jacks. Obviously, it would be safer to use insulated hookup wire.

Checkout and Use

With the ICs still not installed in the sockets on the audio and video boards, plug the line cord of the Distribution Amplifier into an ac outlet and, if you included it, set the POWER switch to ON. Use a voltmeter set to 20 volts dc or so full-scale to check for the presence of the proper voltages at the appropriate points in the circuit. All measurements should be made with reference to circuit ground (in this case, you can use the metal chassis of the project's enclosure). On the power-supply board, you should measure +12 and −12 volts at the + lead of *C3* and − lead of *C4*, respectively. You should also measure +12 and −12 volts at pin 7 and 4, respectively, of *IC1* on the video board. Finally, you should measure +12 and −12 volts at pins 8 and 4, respectively, of *IC1* on the audio board.

If you do not obtain the proper indications, power down the circuit and correct the problem before proceeding further. Start with the power-supply board. If you obtain the proper measurements, proceed to the video board. If you get just the reverse of the correct measurements, you cross-connected the power bus wiring; to correct this, simply transpose the two wires going to the video board. The same applies for the audio board. If the voltages are reversed on both the audio and the video boards, it is easier to transpose the wiring at the power-supply board.

Once you are satisfied that everything is working as it should, power down the project and pull the line cord from the ac receptacle. Now handling the ICs with the proper precautions for MOS devices, plug them into the sockets on the audio and video boards. Make sure you install the proper IC in each case, and make sure that no pins fold under the ICs or overhang their sockets.

Rotate the control shafts of the GAIN controls to determine where their midpoint settings are. Adjust each to its midpoint. Then carefully and without disturbing the settings, push a pointer-type or other indicating knob onto each pot shaft so that the indicator is pointing straight up. This is the unity-gain position for each control.

When the Audio/Video Distribution Amplifier is connected into your home-entertainment system and is powered up, turning any knob clockwise should increase the gain, while turning it counterclockwise should reduce the gain. If this is not the case with any given control, power down the project and transpose the two outer wires going to it.

The normal operating position for the GAIN controls should be straight up at the unity-gain setting. Whenever the GAIN controls are used, always be sure to make a test recording if one of the outputs is going to a VCR before making the actual recording. Check the test recording to make sure no stages of the VCR are being overloaded.

You should now have the makings of a fine-performing audio-visual home entertainment system. **ME**