



Closed-Caption Decoder

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Last month we looked at the theory and the circuitry behind the closed-caption decoder. Now let's build one.

Part 2 WHEN WE FINISHED UP last time, we discussed the basics of how closed captioning works, and we presented the complete schematic diagrams of our closed-caption decoder. Now you can warm up your soldering iron—we're ready to build the circuit.

Construction

Building the decoder is fairly easy because it has only a single IC, and because all components, except the switches and power jack J1, mount on the PC board.

The NCI telecaption module, the heart of the decoder, mounts in the bottom of the case, and the PC board mounts in the top. The close quarters in the case require that all components on the PC board be low-profile types with heights less than one inch. The only problem component is the 7805 regulator, which requires a relatively large heatsink. We solved the problem by installing a vertical-mount heatsink horizontally.

To begin construction, first inspect the PC board (whether you make your own or buy the kit) for plugged holes and broken or shorted traces. Fix any and all faults before proceeding.

Following the component-placement diagram in Fig. 7, install the three jumpers using 22-gauge bus wire. Keep the jumpers tight and flat against the surface of the board to prevent shorts. Next, insert 26 PC pins into the holes in the board where wires will connect: 15 along the right edge of the board (where the NCI module will connect), two for J1, two for S2, and seven for S1. Turn the board over

carefully and rest it on the pins while you solder them in place.

Next install the 59 fixed-value resistors. The holes for all the resistors are spaced so that the leads of each resistor can be bent right at the body. To ease troubleshooting, mount the resistors so that the color codes point the same way.

Install the capacitors, taking care to orient the polarized electrolytic and tantalum types correctly. Keep all the capacitors as close to the board as possible, bending their leads if necessary to match the hole spacing.

Install the diodes next, taking care both to orient them correctly and not to mistake the different types. In particular, be certain that the 6.2-volt Zener is inserted in the D3 position, and that the 8.2-volt Zener goes in the D11 spot. Use care in bending the leads of the diodes, particularly the glass types.

Now install the transistors. To avoid mixing up the two types, first insert and solder the five PNP devices (Q3, Q5, Q10, Q13, and Q14). Then insert the nine NPN transistors in the remaining positions, and solder them in place. Keep the transistors close to the board—their cases should be no more than 1/4 inch from its surface.

Press the four RCA jacks (J2, J4, J5, and J6) into the board and bend their tabs over to hold them in place. Check that they are all firmly and squarely seated, then solder them in place, using a fair amount of solder to obtain firm joints.

Insert the two trimmer resistors, R50 and R55, into the board and solder them in place. Be certain that they are well

mounted, so that repeated adjustments will not work them loose.

Press the RF modulator into the board and twist its lugs to hold it in place. Solder the lugs to the foil, using plenty of solder to make a secure joint. Not only do the lugs hold the relatively heavy modulator in place, but they are used as jumpers to extend the ground plane to two points near the center of the board. Poor mounting will cause problems. Insert the modulator's four leads into their holes, noting that they angle back from the edge of the board slightly. Pull the leads tight, then solder them.

Now install the 7805 regulator and its heatsink. The heatsink supplied with the kit has two pins extending from one end to facilitate vertical mounting. Since the heatsink will be mounted horizontally, remove the pins with a pair of pliers.

Insert the 7805 regulator into the board with its metal tab toward C1, and then bend it so that the hole in its tab lines up with the hole in the board. DO NOT solder its leads yet.

Pass the heatsink's mounting screw through the PC board and through several metal washers to hold the regulator slightly above the board. Apply a layer of heatsink compound to the back of the 7805 and attach the heatsink, tightening the screw firmly. Solder the regulator's leads now.

The last step in building the PC board is to mount power-on indicator LED2. It must extend from the edge of the PC board to meet its mounting hole in the front panel. The easiest way to determine its mounting position is to temporarily fit the

help the decoder to remain trouble-free in changing humidity conditions.

Interconnections

The connectors that couple our board to the NCI module are an unusual type with 0.1" spacing between adjacent pins. They are insulation-displacement types, so you need only press a strand of ribbon cable into each contact. We use three connectors of different sizes: four-, five-, and six-contact points. Each interconnecting cable has a connector only at the end that attaches to the NCI module; the other end is soldered to the PC board.

Cut three pieces of ribbon cable about six or seven inches long, one each with four, five, and six conductors, and separate the conductors about one inch at each end. Insert the unstripped wires into the "bays" of the appropriate connector and, holding them in place, pull the cable down across the terminals, but don't apply too much pressure. With the cable seated, use a small flat-blade screwdriver to push each wire into the notch of its terminal.

Strip about 1/4-inch of insulation from the other end of each conductor of all three ribbon cables. Twist the strands together, and then solder the wires to the PC-board pins. Make sure that you solder those wires so that the connectors at the other end will be able to fit in the NCI module. Figure 8 shows how they should seat. The six-conductor cable should be split for an inch or so at the PC end between its second and third conductors in order to clear C15. Or you could push C15 so that it lies flat on the board. Don't break its ceramic coating or short any of the other connecting pins. After all of the wires are soldered in place, inspect your work and correct any errors.

Attach J1 and S2 to the rear panel, and insert the panel into the top half of the case. Install the PC board and secure it with four self-tapping screws. Make sure that the jacks line up with the holes in the panel.

Connect wires between J1's pins and the appropriate pins on the PC board. Then connect S2 to the channel-select pins, using segments of ribbon cable or other 20- to 24-gauge hookup wire. Keep the wires short and neat, but leave a small amount of slack to allow removal of the board or the panel.

Remove the anti-rotation lug from rotary switch S2 and mount the switch to the front panel, tightening its nut finger-tight. Fit the knob to the shaft and adjust the switch's position so that the knob's indicator lines up with the panel markings. Carefully remove the knob and tighten the nut. Then re-install the knob and make sure that the indicator still lines up.

Use bus wire to connect the five common terminals of S1-a together. Clip the terminals off just above the wire, and re-

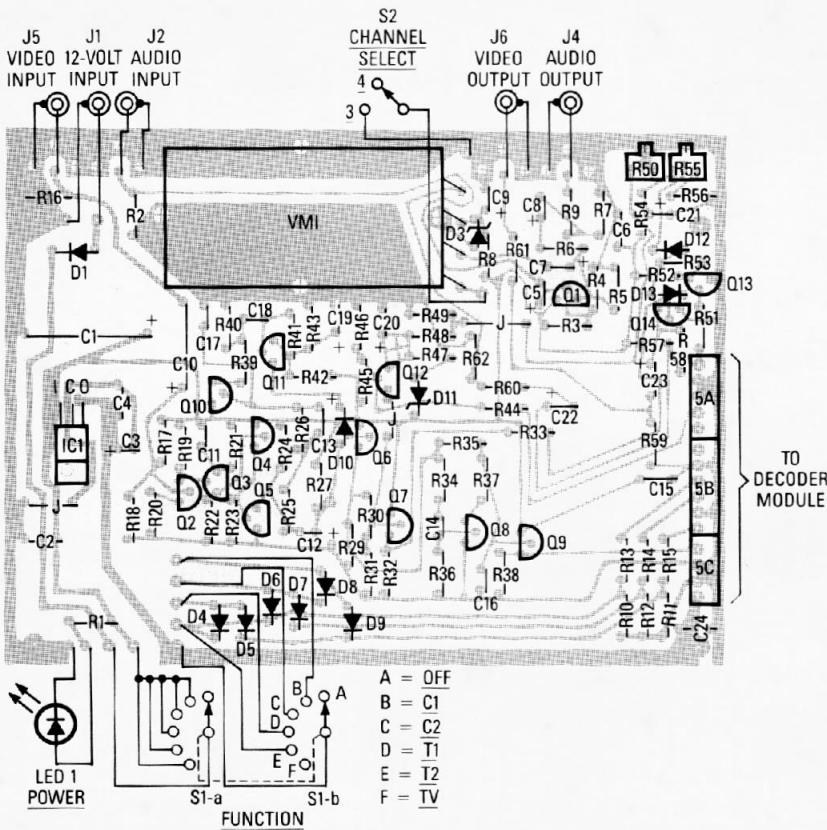


FIG. 7—MOST COMPONENTS EXCEPT THE SWITCHES AND J1 mount on the PC board. Use PC-board pins to connect the off-board components.

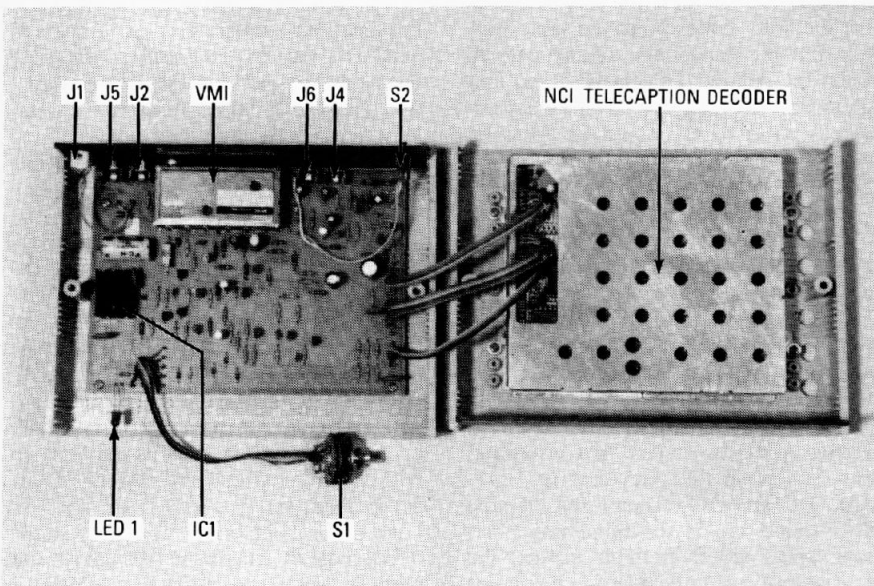


FIG. 8—THE PC BOARD MOUNTS IN THE BOTTOM of the case and the NCI decoder module mounts in the top. Make sure that the three jumper cables connecting the PC board and the module are oriented correctly.

PC-board and the front panel into the case. After the LED's leads are bent to fit, remove the board and solder the LED in place. Note that the lead next to the flat edge of the LED's case goes to the hole nearest the corner.

After all components have been mounted, inspect your work for incomplete joints and solder bridges, and correct any problems. Clean flux from the bottom of the board, and then spray it with an acrylic dielectric spray. Doing so will

PARTS LIST

All resistors are 1/4-watt, 5% unless otherwise noted.

R1, R22, R23, R52, R53, R56, R60—1000 ohms

R2—15,000 ohms

R3—270,000 ohms

R4—100,000 ohms

R5—22,000 ohms

R6—390 ohms

R7, R40—4700 ohms

R8, R58—180 ohms

R9, R20, R21—560 ohms

R10—R12, R17, R28—47,000 ohms

R13—R15, R34—470 ohms

R16, R61—75 ohms

R18—18,000 ohms

R19, R24—680 ohms

R25, R47, R48, R57—220 ohms

R26—180,000 ohms

R27—68,000 ohms

R29, R32, R38—2200 ohms

R30—1500 ohms

R31, R37, R44—3300 ohms

R33, R43, R49—330 ohms

R35—2700 ohms

R36—3900 ohms

R39, R59—10,000 ohms

R41, R45—12,000 ohms

R42—1800 ohms

R46, R54, R62—6800 ohms

R50, R55—1000 ohms, PC-mount, trimmer potentiometer

R51—100 ohms

Capacitors

C1—1000 μ F, 16 volts, electrolytic

C2, C4, C6, C15, C24—0.1 μ F, ceramic disk

C3—1 μ F, 35 volts, tantalum

C5, C13—1 μ F, 16 volts, electrolytic

C7, C8, C19—10 μ F, 16 volts, electrolytic

C9, C21—22 μ F, 16 volts, electrolytic

C10—47 μ F, 16 volts, electrolytic

C11—39 pF, ceramic disk

C12—2.2 μ F, 16 volts, electrolytic

C14—150 pF, ceramic disk

C16—100 pF, ceramic disk

C17—0.001 μ F, ceramic disk

C18—220 pF, ceramic disk

C20, C22—100 μ F, 16 volts, electrolytic

C23—470 μ F, 16 volts, electrolytic

Semiconductors

IC1—LM7805T, 5-volt regulator

D1—1N4001, rectifier

D2—not used

D3—1N4735 6.2-volt, 1-watt Zener diode

D4—10, D12, D13—1N914 switching diode

D11—1N4738 8.2-volt, 1-watt Zener diode

LED1—standard red

Q1, Q2, Q4, Q6—Q9, Q11, Q12—2N2222A NPN

Q3, Q5, Q10, Q13, Q14—2N3906 PNP

Other components

J1—1/8-inch miniature phone jack

J2—J6—RCA phono jack

S1—2P6T miniature rotary switch

S2—SPST miniature slide switch

Miscellaneous: Astec UM1285-8 video modulator, NCI Telecaption Decoder Module, PC board, 12-volt 500-ma wall-mount transformer, case, panels, wire, solder, etc.

Note: A kit (no. K-6314) including PC board, case, and all parts except RF modulator and power transformer is available for \$139 plus \$7.55 shipping and handling from Dick Smith Electronics, Inc., P. O. Box 8021, Redwood City, CA 94063. The modulator (no. K-6040) is available for \$9.95 and the power transformer (no. M-9526) is available for \$6.95. Allow shipping of \$1.50 plus 5% of order. California residents must add 6.5% sales tax. Orders outside the U. S. must include U. S. funds and add 20% of total for shipping.

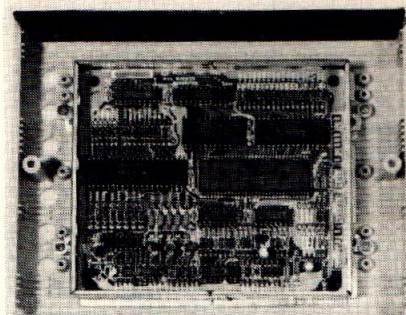


FIG. 9—THE NCI MODULE, shown here with its cover; removed, mounts to the bottom of the case.

rear panel. The module must be all the way back to provide room for the rotary switch in front. Secure the module in place using self-tapping screws and washers. Do not connect the module to the PC board yet.

Testing and adjustment

Turn the rotary switch to OFF and plug the wall transformer's output plug into the power jack. Then plug the transformer into an AC socket and turn S1 to C1. LED1 should light up. Turn the knob through the other positions; the LED should remain lit.

Measure the voltage at the positive lead of C1. It should be no less than 12.5 and preferably no more than 16 volts. (That voltage will drop when the heavy load of the module is added.) Measure the 5-volt supply at either the +5 volt pin of S1-b or at module connector pin 5C4. It should be within 0.25 volt of 5 volts. Finally, measure the voltage at the cathode of D3; it should be between 5.8 and 6.2 volts. If all voltages are correct, turn the decoder off and attach the connectors to the NCI module. Turn the power back on.

move the OFF terminal completely. The terminals must be removed in order for the switch to clear the edge of the PC board. To prevent possible wiring errors, remove the two terminals corresponding to the OFF and the TV positions of S1-b.

Solder a six- to seven-inch length of seven-conductor ribbon cable to the pins near the front of the PC board. Connect the other end to the appropriate points of S1. Insert the front panel into the top of the case.

Drill a row of 3/8-inch cooling holes along the bottom of the left half of the case. Those holes will let air get in to cool the heatsink; waste heat will pass by convection through the gaps around the rear-panel jacks.

Next mount the NCI module in the bottom half of the case. The module has four mounting lugs designed for attachment to a flat surface. To mount the module to the standoffs in the bottom of the case, bend the lugs so that they extend straight out from the module's shielding can; then make an additional horizontal bend about

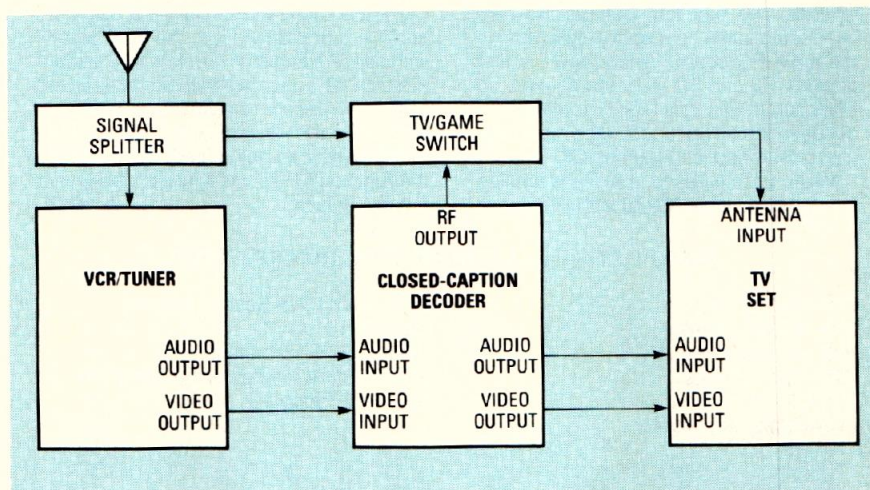


FIG. 10—SYSTEM WIRING DIAGRAM shows how the decoder should be connected to your video system. The signal splitter and TV/GAME switch are optional.

1/4 inch from the first bend. Press the module into place with the connectors on the opposite side of the cooling holes, and with the rear edge against the slot for the

Again measure the voltage at the positive end of capacitor C1. Ideally, it should be between 12 and 12.5 volts, but it may vary, depending on the wall trans-

ELECTRONIC FUNCTION SELECTOR

As promised last month, we'll describe an all-electronic function-selector circuit that can be used to replace the rotary function selector, S1. The circuit is shown in Fig. 1.

clock input; that pulse advances the counter by one. The 0 output goes low and the 1 output (pin 1) goes high, so the C2 LED lights up, and caption channel C2 is selected. Successive presses of S1 cycle

bypass decoding, if necessary.

Select a strong station on the VCR or tuner, set your TV and S2 on the decoder to Channel 3 or 4. Now turn everything on. Place S1 in the TV position.

If the picture and sound on the TV are good, then no adjustments to the modulator are necessary. But if either picture or sound is faulty, use a 1/16-inch flat screwdriver to adjust the modulator's tuning coil (the one nearest the input leads) until the picture is good. Then adjust the other coil until the sound is clearest. You may have to adjust both coils several times to optimize both audio and video.

Set trimmer resistors R50 and R55 to the center of their travels, set S1 to C1, and tune in a captioned program. During the day, the best place to find one is on a PBS station. At night, try either a PBS or an ABC station. On satellite, tune in any of the ABC or PBS feed transponders.

If the captions appear with a dark background and bright, legible characters, no adjustments are necessary. But, if the boxes are too light, if the captions distort the picture, or if dark streaks appear in light scenes, adjust the BLACKNESS control (R50) until the boxes are as dark as they will get without streaks or distortion. If the characters are either too dim or smeared, adjust the CHARACTER control (R55) until they are clearly visible, but not smeared.

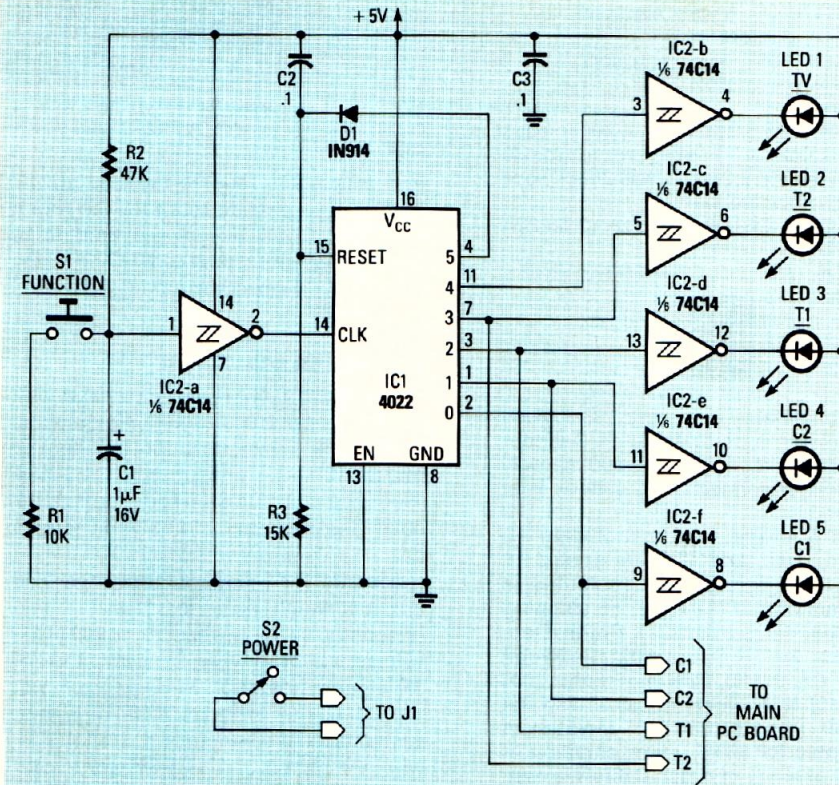
If proper adjustment cannot be obtained in the middle 1/3 of the trimmer's travel (or cannot be obtained at all), the problem is most likely the 12-volt supply. To compensate, one or two of the resistors in the blanking and Y level bias circuits will have to be changed. The resistors should be changed only if it is difficult to get clear captions and background.

If the background will not adjust properly, clip R47 from the board, leaving the lead stubs in place. Connect a 1K trimmer resistor to the stubs and, with the background trimmer set to the center of its travel, adjust the new resistor to obtain a dark background without streaks or distortion. Turn the decoder off, measure the value of the pot, and replace it with the closest standard resistor. If you're careful, you can solder the new resistor to the leads of the old one without having to remove the board from the case.

If it is the characters that will not adjust properly, perform the same procedure, but substitute a 2K trimmer resistor for R56.

After everything is working correctly, disconnect the decoder, assemble the case, and reconnect it to your video system. Now you're ready to enjoy the new world of closed-caption programming.

To conclude, it's our sincere hope that all of the hearing-impaired persons who are aided by this project enjoy using it as much as the author enjoyed designing and developing it and we enjoyed publishing it. It was truly our pleasure.



The heart of the circuit is a 4022 8-stage ring counter. In a ring counter, one and only one output is high at any time. Each output of the 4022 drives an LED via an inverter. The first four outputs are also connected to the corresponding inputs on the main PC board. When power is first applied, C2 and R3 reset the counter, so the 0 output (pin 2) is high. Therefore, the decoder comes up tuned to the most popular closed-caption channel, C1.

When S1 is pressed, a pulse is applied (via Schmitt trigger IC2-a) to the counter's

the 4022 through each of its states; a fifth press returns the decoder to the C1 mode, because the output 5 (pin 4) is coupled to the RESET input via diode D1.

You can build this circuit on a piece of perfboard and attach it to the front panel with spacers and screws. Note that a separate SPST switch will then be required to switch the decoder's power on and off; in addition, power-on indicator LED1 (on the main board) can be omitted, since one of the function LED's will light up whenever the power is on.

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PARTS LIST— ELECTRONIC FUNCTION SELECTOR

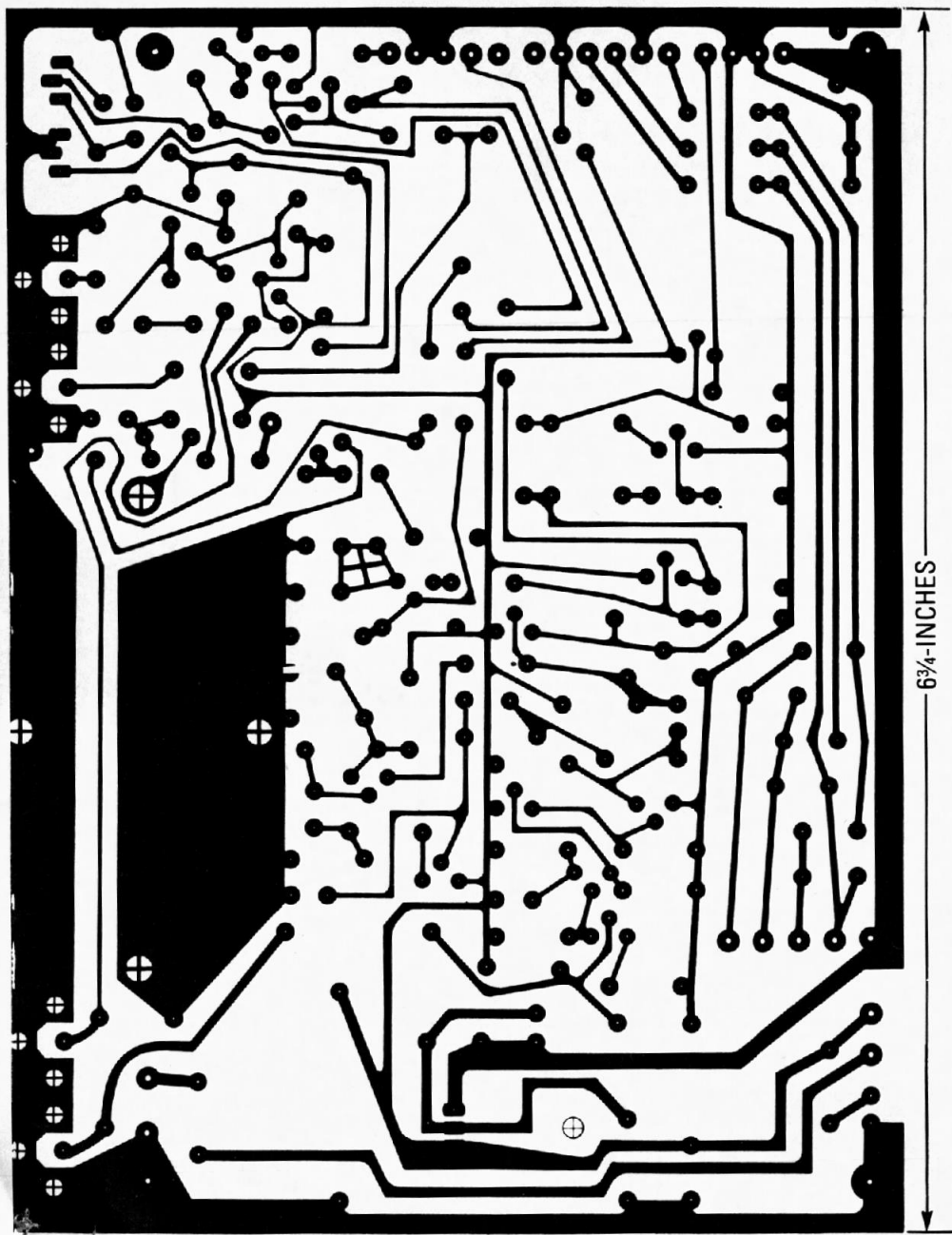
R1—10,000 ohms
R2—47,000 ohms
R3—15,000 ohms
C1—1 μ F, 16 volts
C2, C3—0.1 μ F
IC1—4022 ring counter

IC2—74C14 hex Schmitt trigger
D1—1N914
LED1—LED5—Standard
S1—SPST normally open pushbutton
S2—SPST toggle

former used. To accommodate transformers with various output voltages, it may be necessary to alter the values of several resistors. We'll discuss those modifications in a moment.

Before closing up the case, temporarily connect the decoder to your video system

as shown in Fig. 9. Note that a video switch is shown in that figure; it can be used to bypass the decoder when caption decoding is not needed. If captions will be desired most or all of the time, the switch, and the signal splitter, can be omitted and the decoder's TV mode can be used to



6 3/4-INCHES

THE CLOSED CAPTION DECODER'S PC BOARD IS SHOWN HERE.