# Building a solid-state chroma keyer

By Robert Blauvelt*

One of the most useful and least understood color production accessories is the chroma keyer. Its uses are unlimited. This article describes a chroma keyer that was designed and built by the author at KRDO-TV shortly after the purchase of live color cameras. The unit described equals or exceeds the quality of the average network chroma keyer. If all new components are used, this unit may be duplicated for approximately $150.00.

Chroma keyers are basically quite simple. Fig. 1 shows a block diagram of the one built at KRDO-TV. This unit consists of Darlington pair input amplifiers driving a three input, two output matrix. Here the colors are added and subtracted to derive a keying waveform corresponding to any given color. This keying signal is then further processed in a high gain differential amplifier, clamped, black clipped, and delayed with a variable delay line. The delay line is used to compensate for encoder and cable delays in the studio system.

A common base amplifier is used to provide the necessary gain to overcome circuit losses and to drive the totem pole output state to 0.7 volt pp. Sync is applied to the unit for clamping purposes. The sync enters via a Darlington pair and is amplified and inverted to drive the clamp transistor.

The purpose of all this circuitry is to develop a positive-going signal, coincident in time with the camera's scan of the particular color area to be keyed. This positive signal (normally 0.7 V pp.) is applied to the station's special effects system via an external key input. Thus a particular color tells the special effects system when to switch.

Although blue is normally used

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**Fig. 2** Coarse hue control is at left, fine hue is second control from left. Balance adjust is between fine hue and gain controls.

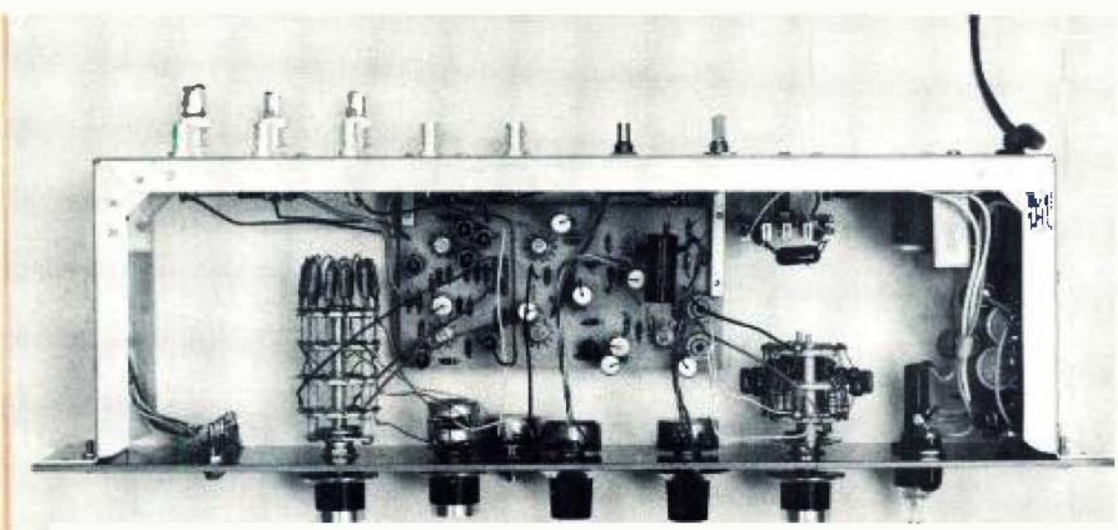


**Fig. 3** Top view of keyer with panels removed.

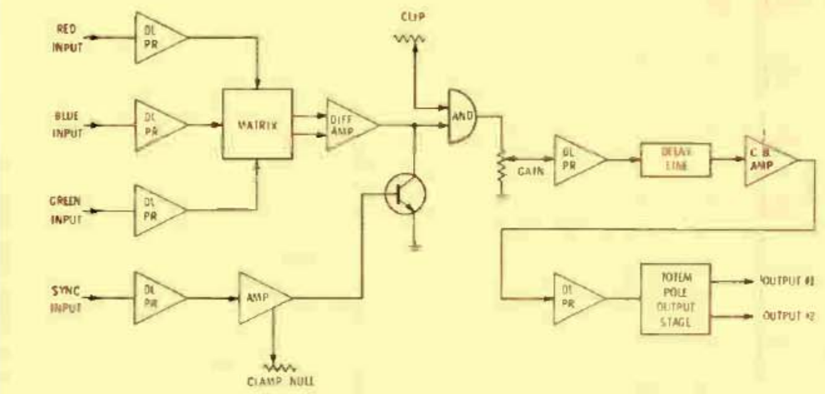



**Fig. 1** Chroma keyer block diagram.

as the keying color because it is the least prevalent in flesh tones, any color may be used. The primary colors, (red, blue, and green) tend to work the best, however.

### Construction

The actual unit is assembled on a 3½ inch rack panel and bathtub chassis (see Fig. 2). The matrix and delay line should be preassembled before mounting to the front panel. The matrix, with the exception of the dual 200 ohm pot, is wired on the switch. The delay line is assembled on the switch, except for the termination resistors which are mounted on the printed circuit board.

The lettering on the author's front panel is letter press, which should be available in your local art store. After the lettering is applied, a few coats of lacquer should be sprayed over the panel to prevent the letters from rubbing off. Once the front panel is assembled, it should be set aside until the main chassis is finished.

The major portion of the circuit is on a printed circuit (see Fig. 3). Fig. 4 is the schematic of the keyer less matrix, power supply, and delay line. The omitted circuits are Figs. 5, 6, and 7). There are six IC's and six transistors used in the active circuits. IC's one and two are RCA CA 3036 dual Darlingtons. These are used as matching and isolation between the high impedance loop through inputs and the low impedance matrix. The second half of IC 2 is biased a little differently from the other Darlington Pairs so that it will pass negative-going sync instead of positive-going video. The outputs of these are fed to the matrix via voltage dividers, which will be used to provide an effective return path to ground for IC 3.

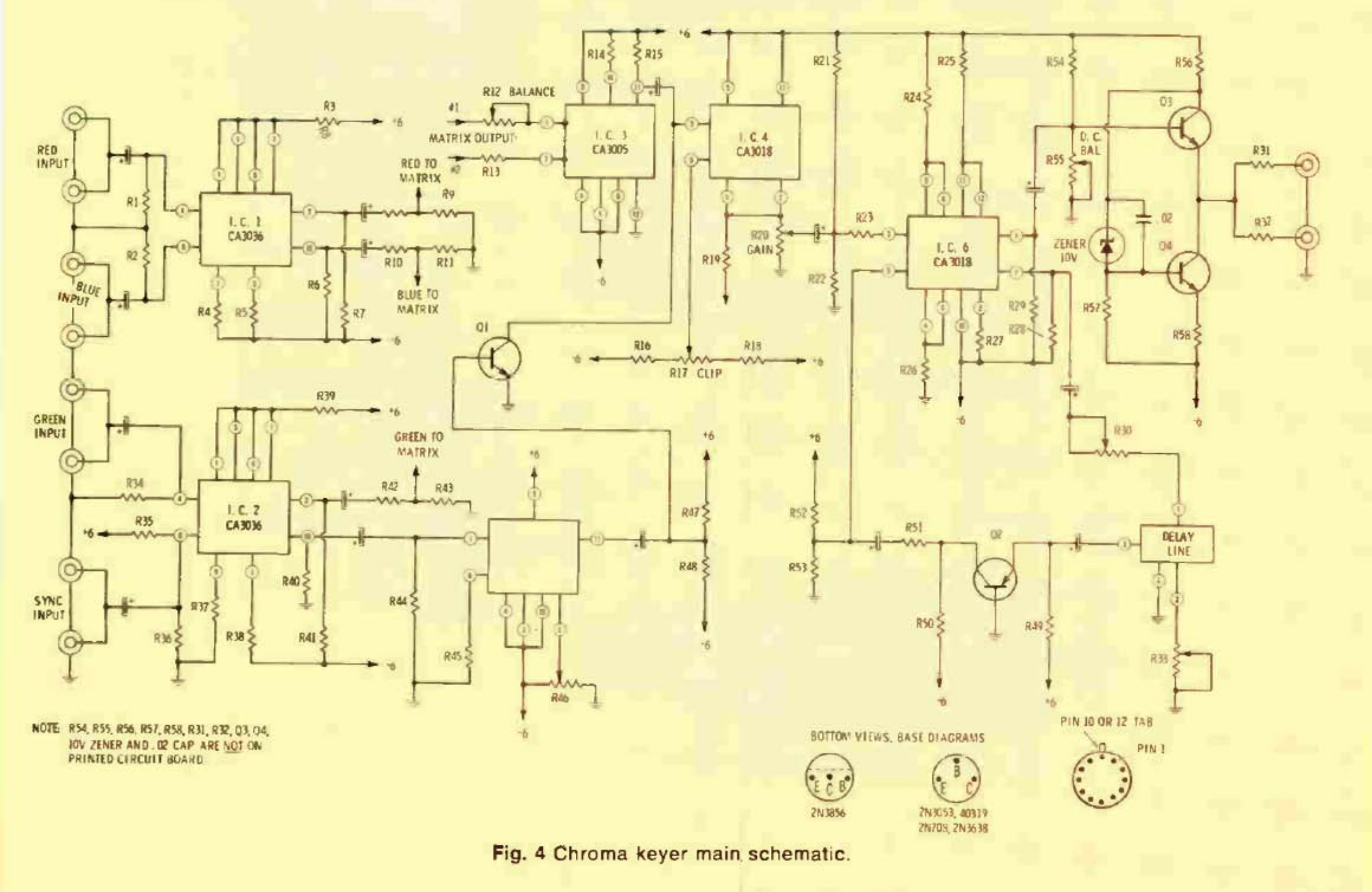
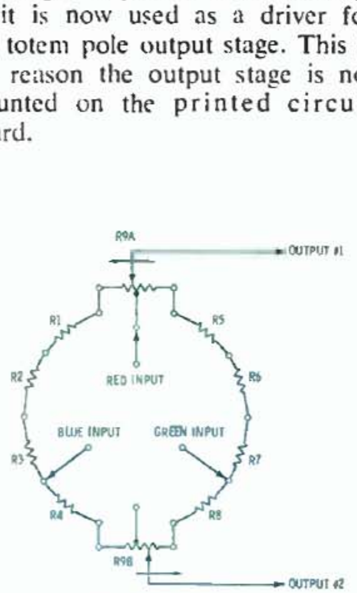



**Fig. 4** Chroma keyer main schematic.

The output of the matrix is fed to IC 3 (RCA CA 3005- high gain differential amplifier), via R-12 and R-13 which are used to balance out circuit tolerances. The output of the differential amplifier contains positive-going video corresponding to the selected color. It also contains negative-going video corresponding to unwanted colors. The output of IC 3 is clamped to ground by Q-1 during the horizontal sync period. This allows IC 4 to clip off all of the undesired portions of the signal without DC drift. R-17, the clip pot, is mounted on the front panel for this purpose. After the video is clipped, the remainder is amplitude controlled by the front panel gain control (R-20).

IC 6 is used as a delay line driver and as an output driver. The IC is an RCA CA 3018, a four transistor array in which two of the transistors are internally wired as a Darlington pair. One half of this IC feeds the delay line via R-30, the sending end termination. The other delay line termination is R-33. The output of the delay line is amplified by Q-2, a common base amplifier which provides high gain with no signal inversion.

After amplification, the signal passes through the second half of IC 6. This is wired as a Darlington pair and served as the original output stage. It proved unsatisfactory, so it is now used as a driver for the totem pole output stage. This is the reason the output stage is not mounted on the printed circuit board.




SWITCH IS 3 POLE 12 POSITION (CENTRALAB PA-2009 OR EQUIVALENT)
R1, R2, R3, R4, R5, R6, R7, R8 = 100Ω 1% 1/2 WATT
R9A AND R9B = DUAL 200Ω POT WITH CENTER TAP (RCA #94911)
THIS MAY BE ORDERED FROM: RCA PARTS AND ACCESSORIES
P. O. BOX 100 DEPTFORD, NEW JERSEY 08096

**Fig. 5** Chroma Keyer matrix.

IC 5 (RCA CA3001) is used as a variable gain, sync inverting amplifier to drive Q1, the clamp transistor. It was planned to also take the negative output of this IC and, by resistive mixing, make one output composite. This caused some problems in the output circuits and was later deleted. The gain of IC 5 is controlled by the pot labeled "Clamp Null."

The totem pole output stage consists of a pair of series connected 2N708 transistors biased so that the common emitter-collector point is at 0.00 volts DC—thus no output capacitor is required.

The power supply, input and output BNC connectors, clamp null pot, and DC balance pot are all mounted on the bathtub chassis. The power supply is all "hard wired." It could be assembled on a PC board if desired.

The power supply is actually two supplies derived from one transformer. The regulators are a simple zener diode reference series circuit that seem to do an excellent job of removing all ripple. It is strongly recommended that the supply voltages not be varied from a nominal plus and minus 6 volts (±½ volt) because of IC limitations. The voltage will vary a little, however, due to zener tolerances.

The matrix schematic shows a switch with three wipers. This is actually a three deck switch interwired so that the wipers are 120 degrees apart. The photographs of the keyer that show the matrix show a four section switch. This was an older design and since has been replaced.

The printed circuit board may be duplicated if desired, however, the keyer works just as well built upon Vectorboard as did the prototype. The printed circuit board is set up for ¼ watt resistors and normal small size transistor capacitors mounted on end. The ultra sub-miniature tantalum capacitors were not used due to excessive cost. It should be noted that three resistors were mounted on the foil side of the board due to wiring complications. These are R-27, R-28, and R-29. They may be seen in the lower left corner of the bottom view in Fig. 3.

### Keyer Setup

After the keyer is built and all obvious errors are removed, disconnect the plus and minus 6-volt lines from the power supply. Load each regulator with a 2.7 K ohm resistor and apply power. The regulator outputs should be plus 6.2 volts and minus 6.2 volts ±½ volt and should show little, if any, ripple on an oscilloscope. When the power supplies are operating correctly, they may be reconnected to the rest of the circuits. Apply standard stairstep to the red, blue, and green inputs. These should be looped from one feed and terminated at the last input. With the oscilloscope attached to the hot end of the gain pot, adjust the balance pot (R-12) for video cancellation of the entire stairstep. This pot is then locked in place. R 55 is now adjusted for 0.0C volts DC at the keyer output with the gain control set a minimum. The only remaining adjustments are for the delay line.

With the oscilloscope connected to the output of the keyer, the stairstep applied to only one input (red, blue or green), and sync applied to the sync input, adjust the gain and clip controls so that only the last step remains which is 0.7 volt pp. The matrix switch may have to be rotated to achieve positive-going video under these conditions. R-30 and R-33 are alternately adjusted for the flatest top and sharpest fall on the trailing edge of the observed pulse. The delay line should be set to maximum delay for this adjustment. It should be possible to adjust the terminations so that the delay line will pass the signal with only slight distortion, if any.

### Keyer Checkout

The final checkout is subjective. Apply the red, blue and green color bar drives to the appropriate inputs and terminate the looping connections. One of the keyer outputs is applied to the external key input of the station effects unit. With encoded color bars applied to one of the effects' inputs, adjust the coarse hue, fine hue, gain, and clip controls for a clean keying-out of the desired hue or bar. The delay line is now adjusted to exactly position the key-out area under the replaced video.

If everything is working to complete satisfaction, the keyer is now ready to be mounted in one of the live cameras. The red, blue and green inputs should be supplied with processed video of approximately 0.7 volts pp. If the second keyer output is applied to a video monitor, the keying signal will be viewable as a white-on-black picture, with the white areas corresponding to the keying color. This is very useful in initial setup and any later color changes. This chroma keyer has proven reliable and should run for weeks without any adjusting.

Having only one chroma keyer is almost the same as having only one VTR machine. With this in mind, you might want to build one for each color camera or even install an input transfer switch so that one keyer may be used with more than one camera. The possibilities for modifications are endless. ▲

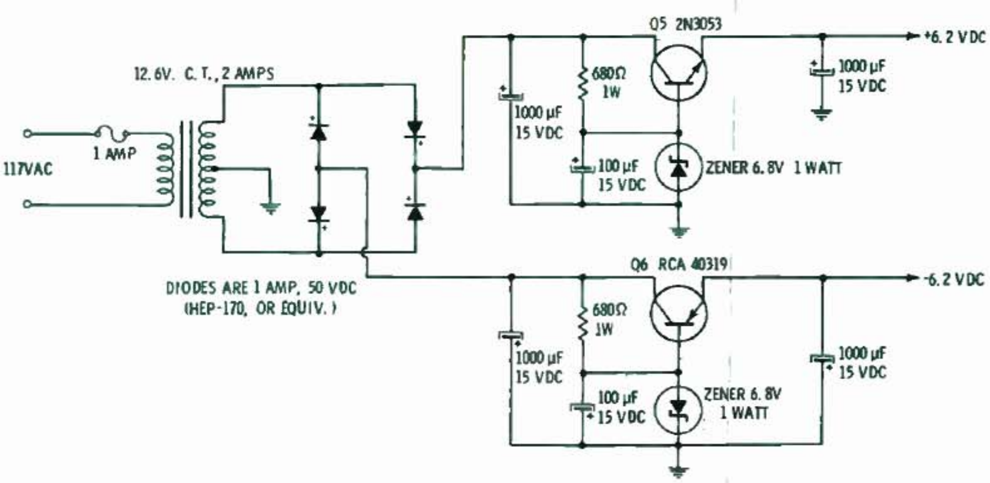



**Fig. 6 Power supply**

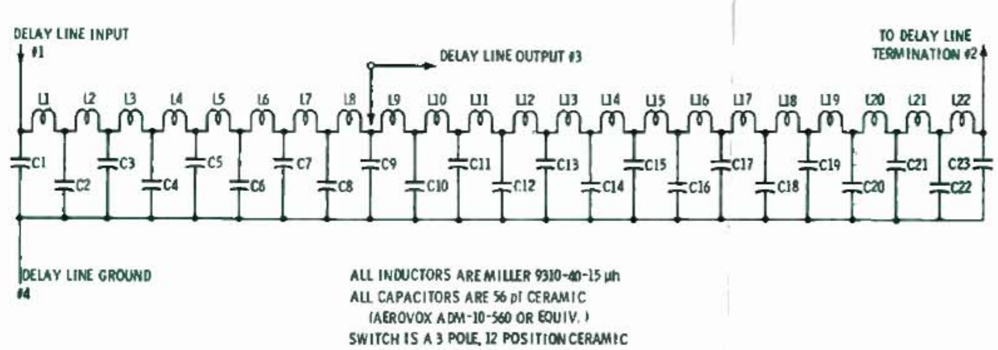



**Fig. 7 Keyer delay line**

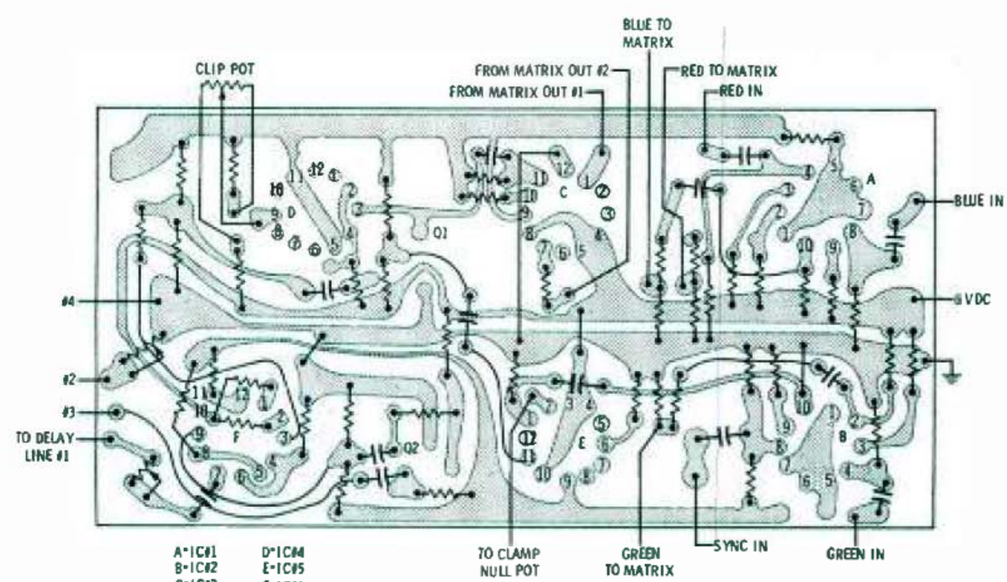



**Fig. 8** Bottom view of printed circuit board parts layout. Top view shown in Fig. 3