

How To Localize Video Camera Problems With The CVA94 "V ideo Tracker"

A properly working video camera produces a composite video output signal. The luminance, chroma, and sync signals that make up this composite video signal must have the proper amplitude, frequency, and phase relationships. Additionally, the composite signal should have minimal noise and be free from other signal interferences. Defects or performance problems in the camera alter the composite video output signal. How quickly and accurately you diagnose defects in the video signal and relate them to the camera's functional blocks affects your success in camera servicing.

This Tech Tip tells you what defects to look for in the camera's composite video output signal, and explains how to relate these defects to the camera's major signal blocks.

To understand how problems in the composite video output signal relate to defects in the camera's circuits, we need a basic understanding of a color video camera's functional blocks.

Video Camera Block Diagram

A video camera's composite video output signal is really a combination of separate luminance, chroma, sync, and burst signals. The camera's circuitry produces and processes these individual signals separately before assembling them at the camera's video output.

Figure 1 shows a simplified block diagram of a color video camera. Let's briefly review the functions of the major sections. (For more information on how video cameras work, refer to Tech Tip #228, "Understanding How Color Video Cameras Work.")

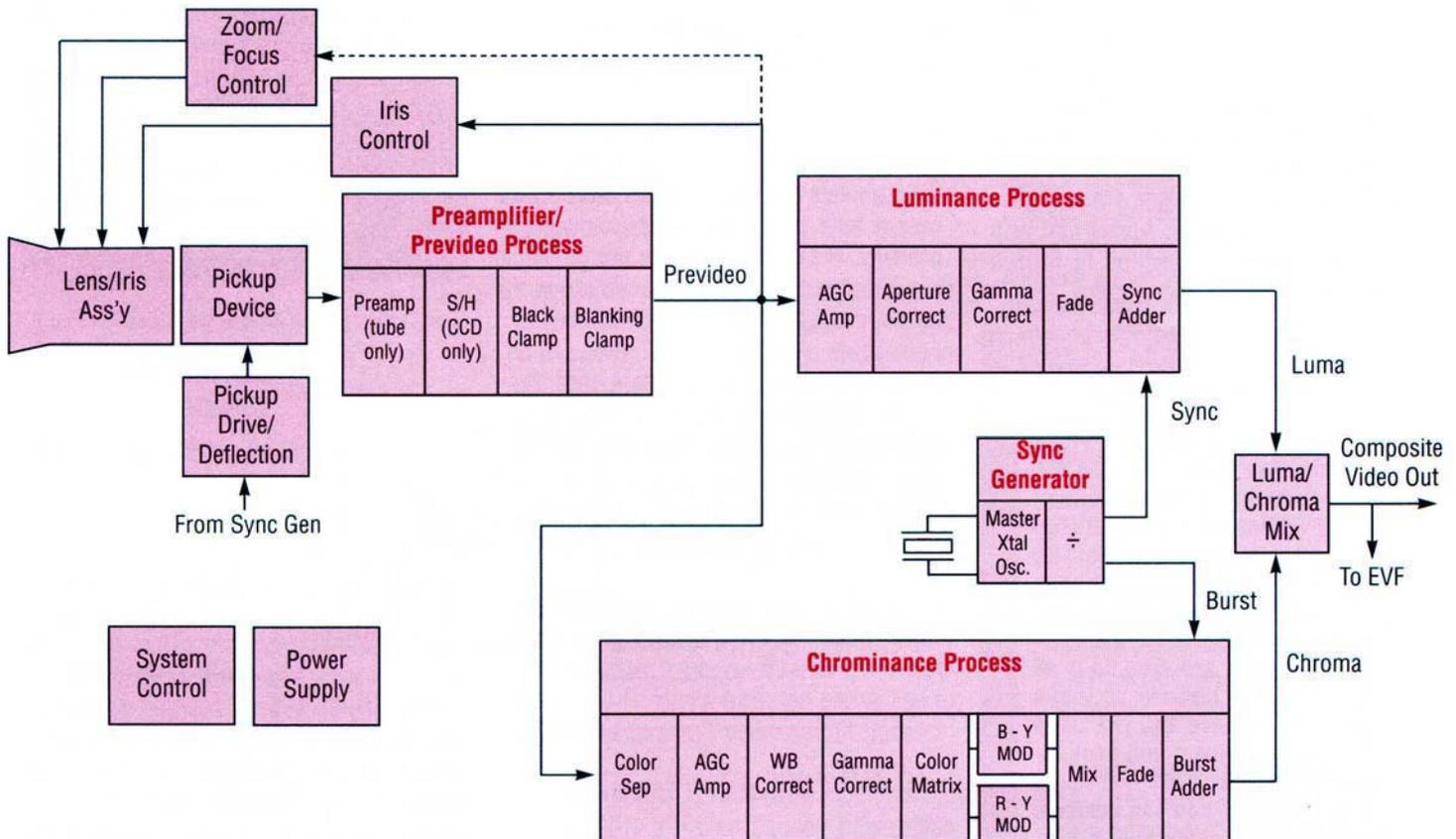


Fig. 1: Simplified block diagram of a color video camera

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Prevideo

The lens/iris/motor circuits position the lens to focus the light from the scene onto the pickup device. The pickup device is scanned by signals from the sync generator. As the pickup device is scanned, the light from the scene is converted into an electrical "prevideo" signal. This prevideo signal, which includes both color and luminance (black and white) information, enters the "Prevideo Process" blocks where sensitive amplifiers boost the signal level and clamping circuits establish the black and blanking reference levels of the signal.

The output of the prevideo process block is video and color carrier—there are no sync or burst signals present. The color carrier signal is not yet in a standard video format that can be used by other standard NTSC video devices. After the Prevideo Process blocks, the video signal is separated into its chroma and luminance components for additional processing.

Luminance Process

The "Luminance Process" blocks process only the luminance (black and white) portion of the signal. An AGC stage maintains a constant signal level for varying light level conditions, and the Aperture or Edge Correct circuit speeds up the black-to-white and white-to-black transitions to increase picture sharpness. The Gamma Correct stage expands the black portion of the signal to compensate for the nonlinear conduction of picture tube CRTs. A Fade block allows the user to fade the camera's output to black. Finally, horizontal and vertical sync pulses are added to form a complete luminance (Y) video signal.

Chrominance Process

The "Chrominance Process" blocks extract the chroma signals from the color chrominance prevideo signal. After the color signals pass through an AGC stage, the White Balance Correction stage adjusts their levels to achieve white for both indoor and outdoor lighting conditions. Again, a Gamma Correct stage compensates for the nonlinear conduction of picture tube CRTs. The R-Y and B-Y color signals are separated and modulate a 3.58 MHz subcarrier to produce a 3.58 MHz chroma signal. Finally, a burst signal or sample of the 3.58 MHz subcarrier is added. The composite color signal combines with the luminance/sync signal in the Luma/Chroma Mix stage to produce the camera's composite video output.

Sync Generator

The sync generator provides synchronization for all the camera circuits and signals. This block has a master oscillator, operating at a multiple of 3.58 MHz, that is divided down to provide sync, 3.58 MHz subcarrier/burst, and the scanning signals to the pickup device.

Analyze The Composite Video Output Signal

A camera's composite video signal output provides very important information about the camera's operation. First, analyzing the output tells you if the camera is working properly. But if the camera is not providing a proper output, closely evaluating the

composite video signal's defect(s) can direct you to the defective section of the camera.

To thoroughly and accurately evaluate the composite signal, you need reference test patterns for the camera input and a vectorscope and waveform monitor to analyze the individual signals that make up the composite video output signal.

The remainder of this Tech Tip explains what you should look for as you analyze the camera's composite video output, and what circuit blocks to check if the signal is not correct.

Sync Level

The horizontal and vertical sync pulses added to the camera's luminance output are reference signals for the scan oscillators in a television or monitor. The level of the horizontal and vertical sync pulses at the camera output should be approximately 286 mV negative as measured from the blanking level reference, as Figure 2 shows. The sync pulse level must be maintained regardless of the luminance and chroma signals. In other words, whether the lens is capped or if the camera is pointed at a white object, the sync pulse amplitude should be the same.

Symptom if defective - Missing or low amplitude sync pulses in the camera output signal cause sync problems for the video display monitor.

IRE Level Measurement

A more convenient video measurement scale, called the IRE scale (named after the Institute of Radio Engineers), is often used instead of millivolts. In the IRE scale, blanking is 0 units, peak white is 100 IRE units above the blanking level, black setup is 7.5 IRE units above blanking, and sync tip is 40 IRE units below blanking, as shown in Figure 2. Since 140 IRE units correspond to the 1 volt peak-to-peak video signal, 1 IRE unit equals 7.14 millivolts. You can measure video levels in either millivolts or IRE units.

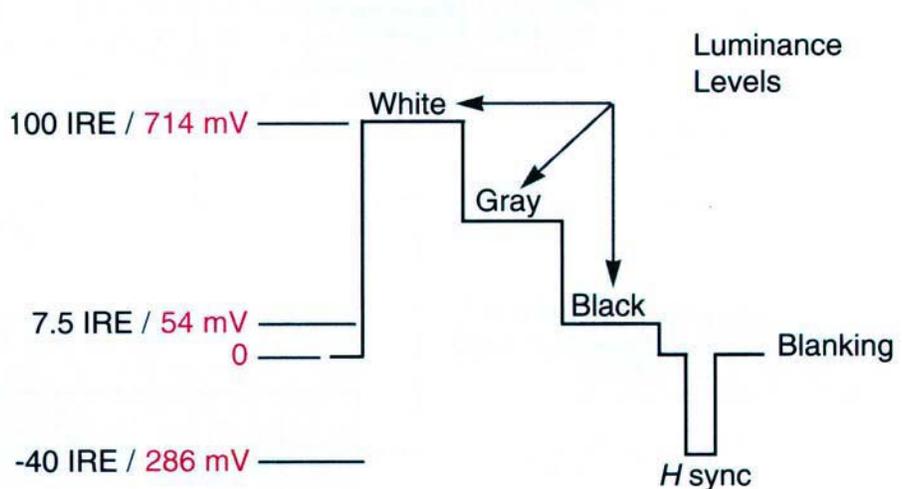


Fig. 2: Proper luminance and sync levels.

Camera blocks affected - Missing or low amplitude sync pulses can only be caused by a couple of stages. The sync adder stage includes an adjustment for setting the sync level. If that adjustment doesn't correct the sync level, check the sync generator for proper operation.

Symptom if defective - If the camera's luminance level is inaccurate, the picture displayed on the output monitor will be too light or too dark.

are typically as low as 76 IRE units. Check the camera's specifications for the proper amplitudes.

Luminance Level

As the camera scans black areas of the scene, it develops a voltage level 54 millivolts more positive than the blanking level in the output signal. This difference in level between blanking and black is "black setup." During white picture areas, the camera produces a voltage level that is 714 millivolts more positive than blanking. Gray areas of the scene produce voltage levels somewhere between these black and white levels. The total amplitude of the video between white and sync tip is 1 VPP. These levels are shown in Figure 2.

Camera blocks affected - If the camera's luminance level is wrong, check the chroma signal level. If both levels are wrong, suspect the circuits in the Prevideo Process block. If only the luminance level is bad, suspect a misadjustment of the luminance level or black setup control or a circuit defect in the Luminance Process block. Table 1 lists several luminance level symptoms and their likely causes.

Check the camera's chroma saturation by scanning a reference color bar test pattern. Measure the amplitude of the camera's chroma signals using a vectorscope or waveform monitor.

Often manufacturers specify chroma amplitudes as a "percentage of burst." This measurement simply specifies the amplitude relative to the normal amplitude of the color burst signal, which is 40 IRE units. For example, 100% of burst is the same as 40 IRE units, and 220% of burst equals 88 IRE units (2.2 x 40).

A camera's video output signal amplitude should remain constant as the light level illuminating a scene changes. The opening and closing of the iris inside the lens assembly regulates the signal level at high light levels. When the light level decreases to a point where the iris is wide open, the AGC circuit increases the camera's gain in an attempt to hold the output signal constant. The combination of iris and AGC action should keep the output level constant over the camera's light level sensitivity operating range.

Chroma Level

A video camera adds chroma signals to the luminance, blanking, and sync signals in the Luma/Chroma Mix stage just before the camera's video output jack. The chroma signal's amplitude corresponds to the saturation of the colors in the scene. Using a standard camera test pattern, red and cyan produce the highest amplitude color test signals, 88 IRE as Figure 3 shows (72 IRE above blanking + 16 IRE below blanking = 88 IRE). Four other test colors, green, yellow, magenta, and blue are also part of the test pattern. These bars have lower amplitudes, as Figure 3 shows. Camera manufacturer's may, however, specify different chroma amplitudes. Common levels for the red and cyan bars

Because most measuring instruments aren't calibrated in % of Burst units, you'll need to measure the chroma signal in IRE units and divide the measurement by 40 IRE to obtain a percentage. The CVA94 CAMERA VIDEO ANALYZER, however, allows you to measure the color signal amplitude directly in percent of burst.

Symptom if defective - If the chroma signal amplitude is wrong, the colors in the reproduced picture will have incorrect saturation. Color objects will appear washed out or too intense.

Camera blocks affected - If the chroma amplitudes don't match the manufacturer's specs, check the chroma gain adjustment. If the adjustment doesn't correct the problem, check the operation of the chroma AGC, chroma amps, modulator and the other amplifiers in the chroma process section.

Level Symptom Cause	Likely Cause
Luma level high at Level Adjustment, all brightness levels.	Luma Level Adjustment, Black Setup Adjustment, Excessive Gain - AGC
Luma level low at all brightness levels.	Luma Level Adjustment, Black Setup Adjustment, Excessive Gain - AGC
Luma level norm. at high brightness, but too small at low brightness.	AGC
Luma level high at high brightness, but norm. at low brightness	Iris not closing properly
Luma level norm. through only small range of brightness levels	Iris not opening or closing properly

Table 1. Symptoms and likely causes when the luminance level changes under changing light conditions.

Color Burst Level

All NTSC standard color television receivers and monitors require a sample of the 3.58 MHz chroma reference signal to properly demodulate and display the chroma output signal. To produce a standard NTSC color signal, a video camera inserts a sample of its 3.58 MHz reference signal during horizontal blanking time. This short sample of the camera's reference signal is the "chroma burst." It is inserted just after each horizontal sync pulse, as Figure 3 shows.

The amplitude of the chroma burst is important for proper color demodulation in video equipment receiving the camera signal. The amplitude of the chroma burst should always be 40 IRE (286 mV) peak-to-peak, independent of the picture content. The burst should be centered above and below the blanking level - 20 IRE units above the blanking level, and 20 IRE units below the blanking level.

Symptom if defective - If the burst amplitude isn't correct, television receivers, monitors, or other video equipment connected to the camera's output may have improper chroma operation. This includes no color, wrong color saturation, or wrong color hue.

Camera blocks affected - Only a couple of stages affect the color burst level. Often, the burst adder stage includes an adjustment for setting the

burst level. If that adjustment doesn't correct the burst level, check the sync generator for proper operation.

3.58 MHz Color Subcarrier Generator and Burst Accuracy

All NTSC color television receivers and monitors use the chroma burst portion of the composite video signal for locking their reference oscillator to properly demodulate the color information. To ensure compatibility with other color NTSC video equipment, it is important that the camera's chroma burst frequency be correct. Although often called 3.58 MHz, the actual color burst frequency is 3.579545 MHz. The camera's sync generator should generate this signal to within at least 100 Hz (preferably 50 Hz) to be sure that color will be properly produced on all receivers.

You can't use a standard frequency counter to measure the burst frequency at the camera's output because a counter can't separate the burst from the rest of the composite video signal. Most test procedures require you to open the camera and connect a frequency counter to the master oscillator test point. The CVA94 CAMERA VIDEO ANALYZER, however, allows you to measure the color burst frequency directly at the composite output signal.

Symptom if defective - If the color burst frequency is not within 100 Hz of 3.579545 MHz, video equipment connected to the camera's output will produce no or wrong color.

Camera blocks affected - If the burst isn't within at least 100 Hz, it should be adjusted to center frequency with the master oscillator adjustment. If the burst won't adjust to the center frequency, the crystal or trimmer cap is likely at fault.

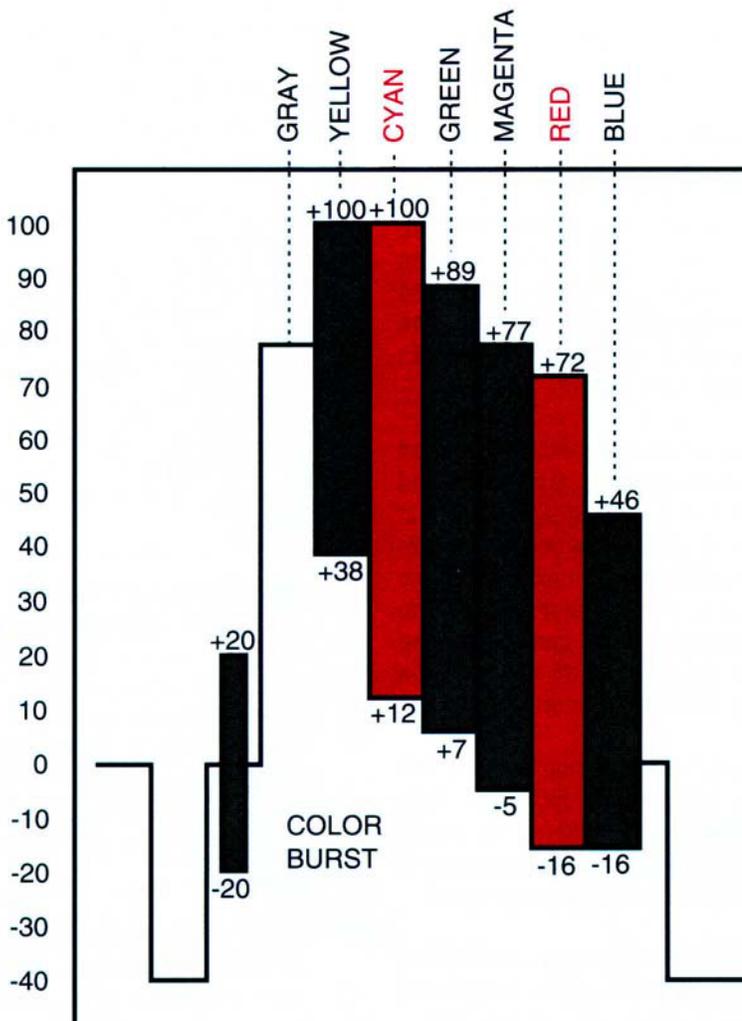


Fig. 3: Proper chrominance and burst levels.

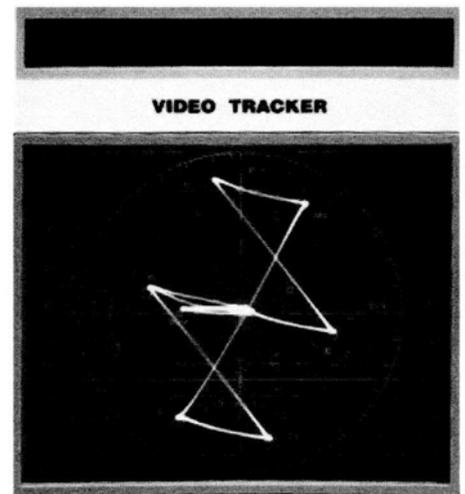


Fig. 4: A vector display compares the phase of the colors to the reference 3.58 MHz or chroma burst.

Chroma Phase

The phase of the chroma signal (as compared to the 3.58 MHz chroma burst) corresponds to the hue or tint of the color in the picture. Each chroma hue or color produces a 3.58 MHz chroma signal with a unique phase.

To test the camera for proper color hues, you will need a standard color bar reference chart and a vectorscope. Point the camera at the reference bar pattern, then use a vectorscope connected to the composite video output signal to check the color phases.

A vectorscope display compares the phase of the burst reference to the other color signals. When the video camera scans the standard colors in the reference chart, the chroma signals should ideally fall within the target boxes on the vectorscope's display, as shown in Figure 4.

The performance of most cameras, however, falls short of this ideal. Be sure to check the specifications for the camera you are testing when deciding whether the chroma phases are proper. Many manufacturers only specify the phase of one or two colors - often just red and yellow. Since flesh tones fall between red and yellow, camera manufacturers strive to produce those colors most accurately, while allowing the other colors to be less accurate due to camera design trade-offs.



Fig. 5: Video noise results in a "grainy" or "noisy" picture.

Video and Chroma Noise

Video noise is small, unwanted random voltage levels in the video signal that appears as graininess in the picture, as shown in Figure 5. Ideally, camera circuits should process the video signal without adding noise. However, noise normally becomes visible under low lighting conditions as the camera's AGC circuits boost the circuit gain to compensate for low light. Visible picture noise at normal light levels, however, indicates a circuit problem in the camera.

To identify which camera stages are responsible for a noise problem, you'll need to determine which part of the composite signal contains the excessive noise. To do this, you'll need test equipment designed for measuring the noise content of the chroma and luminance signals separately, such as the CVA94 CAMERA VIDEO ANALYZER.

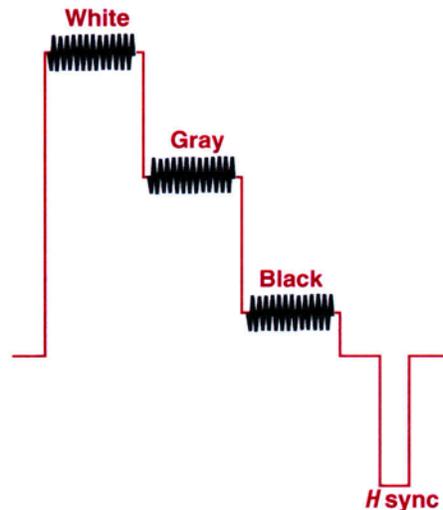


Fig. 6: Amplitude noise adds brightness changes to the picture information.

Luminance Noise

Camera circuits add both amplitude and phase noise. Because the phase of the luminance signal carries little information, only the amplitude noise causes problems. Amplitude noise, as illustrated in Figure 6, adds changes to the luminance signal unrelated to brightness level changes in the picture.

Luminance amplitude noise is compared to the normal luminance signal level, and is expressed as a ratio (S/N), measured in dB. With a 40 dB S/N, the noise amplitude is 1/100th of the signal amplitude. While a 40 dB S/N level or greater is typical in newer consumer video cameras, video S/N ratios greater than 35 dB provide a marginally acceptable picture.

Another type of luminance noise is low frequency interference or "hum." Hum occurs when a poorly filtered DC supply allows 60 Hz ripple from the power line to add to the camera's video output signal.

Symptoms if defective - Luminance amplitude noise causes brightness variations in picture areas that should

be a constant level. The result is a "grainy" or "snowy" picture display on the television receiver or monitor, as Figure 5 shows. This grainy effect also occurs when the camera circuits must operate at maximum gain because of low light content in the picture scene.

Hum interference shows up as ripple in the video signal and as dark horizontal bands moving upward through the picture. Hum interference that produces 5% or greater variations in signal level is objectionable, but 3% hum or greater usually indicates a developing problem.

Chroma Noise

Small amounts of noise which are normally produced in the pick-up device, Prevideo Process and Chroma Process sections combine to produce chroma signal noise. Unlike the luminance signal, both the amplitude and phase of the chroma signal carry color picture information. Therefore, both amplitude and phase noise affect the quality of the color signal. Chroma amplitude noise is often called saturation noise and chroma phase noise is often called hue noise.

Chroma amplitude and phase noise are measured almost the same as video amplitude noise. The noise in the 3.58 MHz chroma signal is compared to the normal signal level, and the S/N ratio is expressed in dB. Typically new consumer video cameras produce chroma saturation and hue signal-to-noise ratios of 40 dB or greater. Cameras producing chroma S/N ratios of 35 dB or greater are usually acceptable.

Symptoms if defective - Chroma amplitude noise causes a grainy picture very similar to video amplitude noise - highly saturated color areas of the picture show a "grainy" effect. When viewed on a vectorscope, chroma amplitude noise causes the vector dots to "jitter" back and forth from the center of the display.

Chroma phase noise causes highly saturated color areas of the picture to have a "smearly" effect. When viewed on a vectorscope, chroma phase

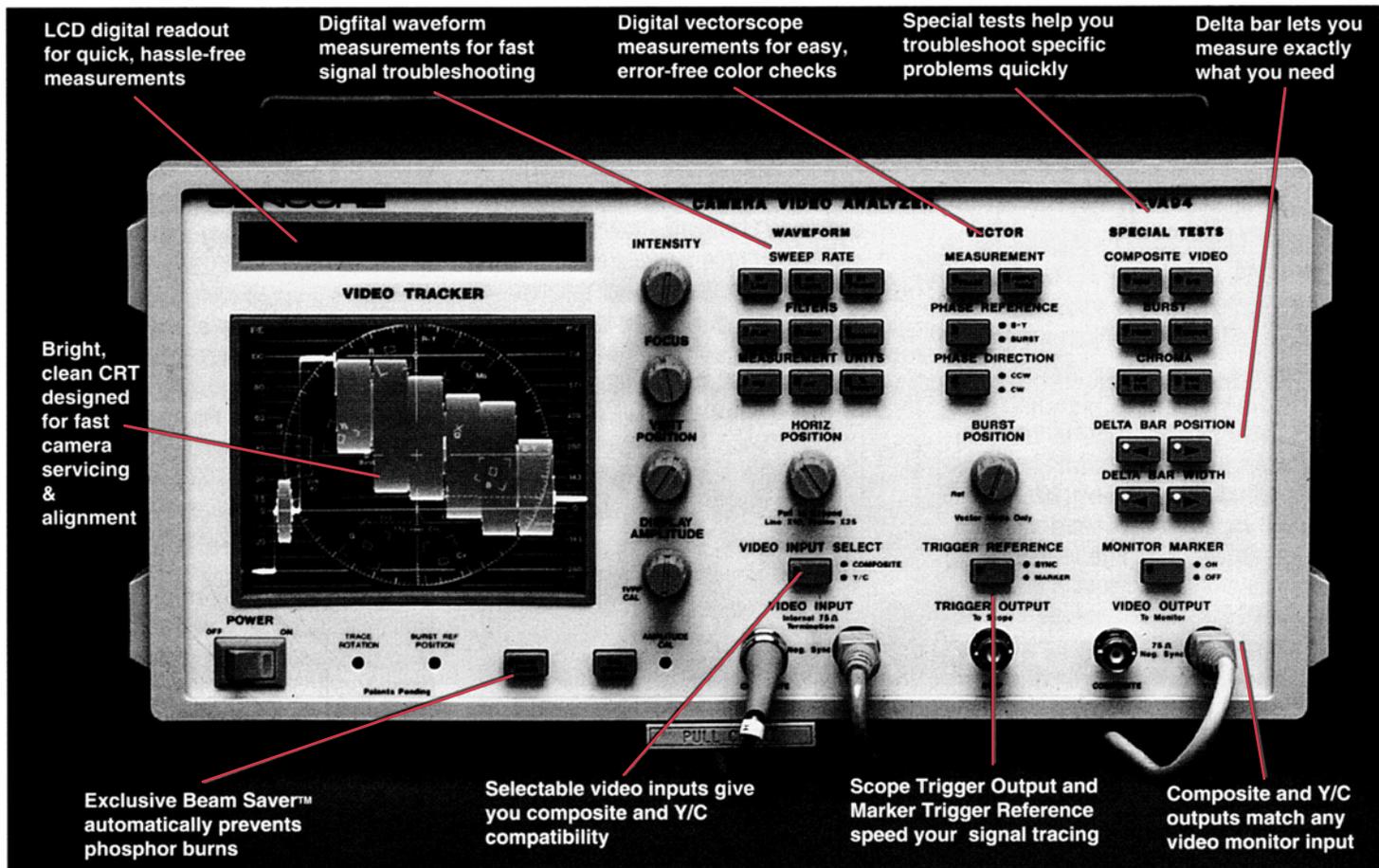


Fig. 7: The Sencore CVA94 Camera Video Analyzer provides you with all the signal analyzing features needed to quickly and accurately analyze a camera's composite video output signal.

noise causes the vector dots to "jitter" circularly.

Camera blocks affected

The type of noise is an important clue for determining which camera block is defective.

Excessive chroma noise and luminance noise: Suspect the pick-up device, Prevideo Process section or iris control. If the camera uses digital signal processing, open or shorted

data lines can cause excessive luminance and chroma noise.

Excessive chroma saturation and hue noise, acceptable video noise: Suspect the Chroma Process section, especially the AGC amp.

Only chroma hue noise excessive: The camera's chroma balance may simply be misadjusted. Check the color balance adjustment and color matrix circuits.

Refer to Tech Tip #232 "Learning To Use The CVA94" for information on how to measure composite video signals, and to Tech Tip # 233 "Understanding The VR940 Reference Patterns" for more information on camera reference patterns.

**For more information,
Call Toll Free 1-800-SENCORE
(1-800-736-2673)**

SENCORE
3200 Sencore Drive, Sioux Falls, South Dakota 57107