

A Guide to Using Waveform Monitors as Artistic Tools in Color Grading

PRIMER



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Introduction

Have you ever had a director ask you if you can fix a few bad shots? Have you ever wanted to make a final sequence look better? Have you ever wondered what colors you are really looking at? Do you ever worry about passing Quality Control (QC)? Color grading can be an intricate and complex process. The human visual system constantly adjusts to the surroundings, making it tricky to know what colors you are truly looking at. Combine that with the challenge of ensuring that your technical standards will pass QC. What's an editor or colorist to do?

Color grading is an important process in creating excellent video productions, and knowing how to use waveform monitors, or “scopes” is critical in doing it right. Whether you think scopes are too technical, or you want to improve your skills, this primer is geared towards editors and will guide you through the process of color correction and using a scope. Whether it's making a final sequence look better or just fixing a few bad shots, this primer is full of tips and techniques to assist you in honing your craft.

For many film and television editors, color correction can appear to be a skill shrouded in a veil of mystery with only a select few possessing the know-how to unlock the secrets of this sometimes elusive world.

Knowing how to use a great scope makes the job of editing and color grading easier and quicker. Editors can get fast results with less rework by keeping the material within the deliverable specifications. Tektronix has the tools to meet the editing demands of getting the job done in both a fast and accurate manner.

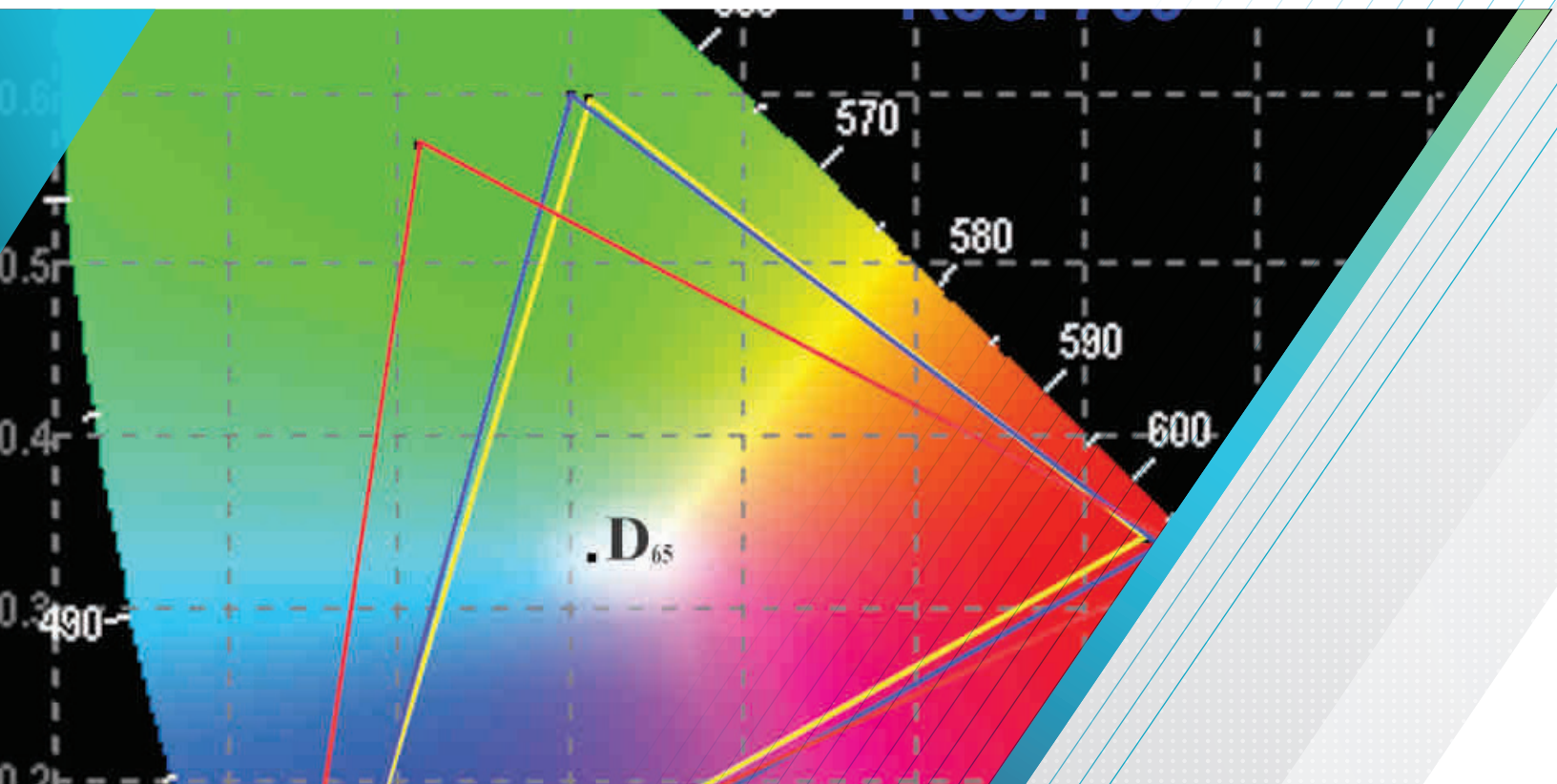
One of the key aspects at the core of doing good color correction for video is making sure that the image can be properly reproduced and delivered to a variety of media and screens. The main technical challenge with maintaining proper color reproduction across a variety of media and broadcast methods is to understand the importance of legal and valid gamut. Tektronix has developed a set of tools that can help editors and colorists easily adjust the color fidelity of the image and maintain the video signal within suitable gamut limits.

By learning how to use these simple, visually intuitive waveform displays from Tektronix, you will improve your color correction skills. For anyone who desires to create beautiful images using color grading software, Tektronix waveform displays are a critical artistic tool, allowing the efficient analysis and manipulation of your images.

This primer is crammed with tips and information on developing color grading as a skillset which can advance your career and set your professional skills apart from other colleagues and competitors. Each section is filled with essential information on developing color-grading techniques as a creative skill set as opposed to just another step in the post process. By using these tools, post-production professionals can gain an invaluable education, expediting future career advancement in their field.

Section 1:

Basic Color Theory and Color Gamut Monitoring



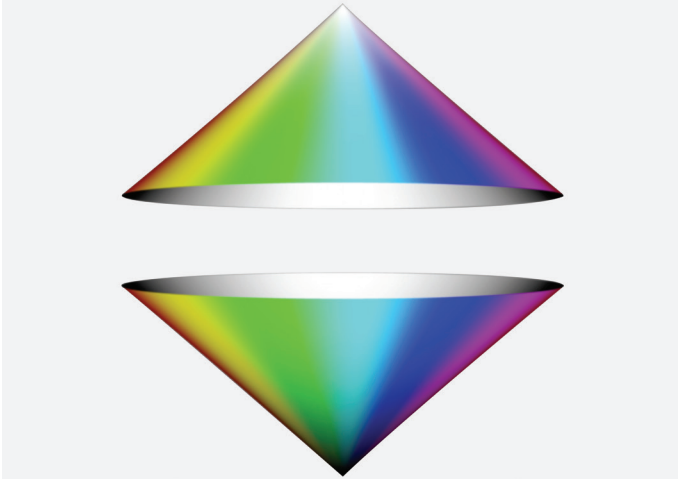


Figure 1-1. Color cones conceptualizing the HSL Color Space.



Figure 1-2. Top view of the Color Cones.

Section 1 Basic Color Theory and Color Gamut Monitoring

There are two things that are at the core of doing good color grading for video:

1. Insuring that the image on the screen looks great and is graded to best tell the story
2. Making sure that the image can be properly reproduced and delivered to a variety of media and screens

In Section 1, we'll concentrate on making sure that the image can be properly reproduced and delivered to a variety of media and screens. The main technical challenge with maintaining proper color reproduction across a variety of media and broadcast methods is to understand the importance of legal and valid gamut. Maintaining proper gamut is crucial in today's world of repurposed content and cross-platform re-distribution of broadcast originated content. Without the ability to accurately monitor gamut issues, there can be problems with broadcast transmissions, recording devices and sponsors and clients whose images are compromised when viewed by certain audiences. Before we examine the concepts of "legal" and "valid", let's quickly review the concepts of color space.

WHAT IS THE HSL COLOR SPACE?

Video is comprised of three color components Red, Green and Blue (RGB), and various combinations of these colors make up the colors we see. One way to understand the Hue Saturation and Luma (HSL), or RGB color space is to imagine it as two cones joined at their widest point (Figure 1-1).

This is what it would look like in three dimensions - the top of the joined cones is white. At the bottom is black. And as the joined cones widen in the middle, that is the representation of saturation. The points or angle around the width of the joined cones represent the hue.

If you look down from the top of the cones, you see a circle with white at the center, and black is directly under it (Figure 1-2). The chroma strength of the signal is indicated by its distance from the center. The closer the trace is to the outer edge, the greater the chrominance or the more vivid the color. The hue of the image is indicated by its rotational position around the circle.

In order to put these concepts into practice, we need to examine how color is measured, in both amplitude and the limits of amplitude.

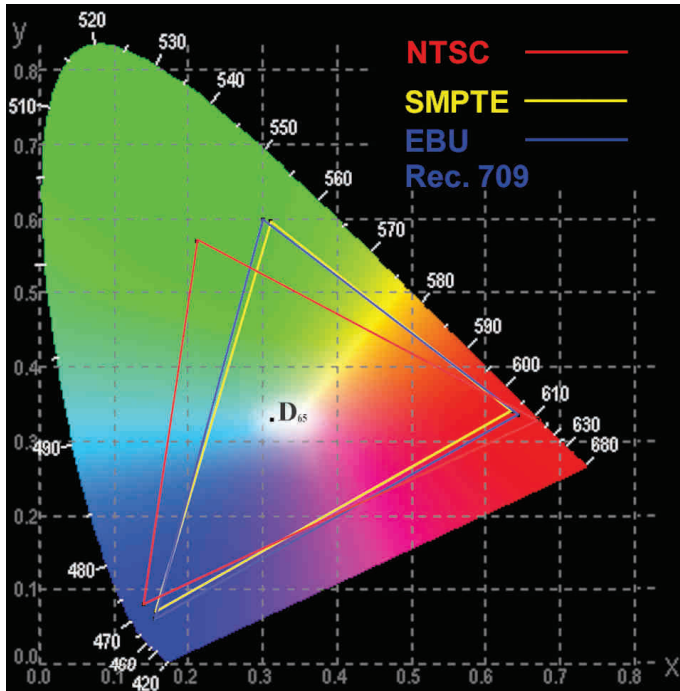


Figure 1-3. CIE xy Diagram with color coordinates used by NTSC, SMPTE and Rec. 709.

Defining legal and valid gamut

The simple definition is that “gamut” is simply a range. Applied to broadcast television, gamut is a range of reproducible colors defined by R'G'B' (red, green and blue) signal values. All colors within the gamut of reproducible colors are possible by independently adjusting the values of the R'G'B' signals. Figure 1-3 shows the color coordinates used by NTSC, SMPTE and Rec. 709.

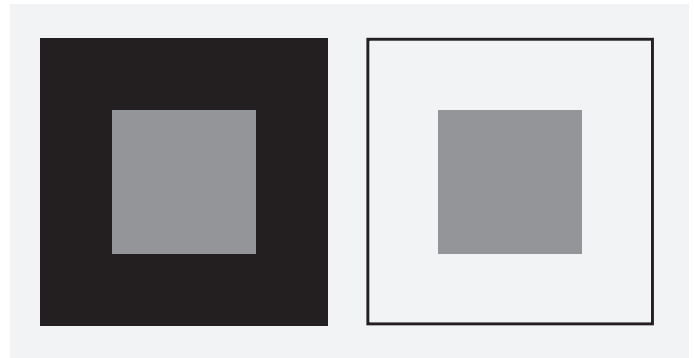
In broadcast video production, R'G'B' values are defined in terms of voltage ranges. R'G'B' signals extending outside the specified voltage range, or gamut, may become clipped or compressed in subsequent signal processing, distorting the color when displayed on another picture monitor. R'G'B' systems have an upper gamut limit of 700 mV and a lower gamut limit of 0 mV. Think of these values as 100% and 0% respectively. Legal broadcast video signals are signals that do not violate the signal voltage limits for a particular format. If any channel of an R'G'B' signal exceeds either the upper or lower limit, it is out of gamut, or out of range. That violation of gamut limits makes the signal “illegal”.

Another type of violation that is possible is called an invalid signal when a signal is converted from one format to another for instance from RGB to YPbPr. In color-difference formats like Y'P'bP'r, it is possible for the current format to be legal within the voltage limits of 700-0mv for Y and +/-350mv for color difference Pb/Pr, but for the gamut to be “invalid” when the current format is translated, transcoded or broadcast in a different format and exceeds the limits for that format and is illegal within this format.

GAMUT AND AMPLITUDE MONITORING

Maintaining proper “gamut” is crucial in today’s world of repurposed content and cross-platform re-distribution of broadcast originated content.

Colorist and editors use their eyes to assess the color and quality of the image. However what your eyes see is interpreted by the brain and this processing can sometimes deceive the viewer. For instance, look at the two simple images below. Which one of the center gray boxes is brighter?



This is a trick question - the gray boxes are actually the same color but the surrounding object influences the brain decision on the color and luma level of the object. Therefore to gauge what you actually see, a waveform monitor (scope) is essential in order to interpret the image information.

The waveform monitor, or rasterizer (scope) is a key tool to help you in providing a legal output of your creative product. Part of the responsibility of the colorist is to ensure that the luma and chroma signals are within certain technical limits. Being a brilliant editor and colorist doesn't mean much if no one will air your product or if the dubs are not viewable. Legal limits are set by broadcasters and cable networks and vary from one to the next. But even if your product isn't being broadcasted, legal levels affect the proper duplication of your project and the way it will look on a regular TV monitor.

Let's take a look at how the waveform and vectorscope can help us as we analyze the images we are attempting to correct. There are probably two groups who are about to roll their eyes and flip ahead a few pages.

- The first group is experienced online videotape editors: veterans who've been using scopes forever. They know all about sync pulse, blanking, back porches, and breezeways, and they aren't interested in sitting through the basics.
- The second group is the new wave of digital whiz kids who have no interest in all the hard-core video engineering stuff that is largely obsolete since the death of the quad machine.

Well, we're not going to be discussing all that video engineering stuff, with the exception of a brief discussion on keeping levels legal. We want to show how these two pieces of engineering equipment can be put to good use as creative tools.

INTRODUCING THE WAVEFORM MONITOR AND VECTORSCOPE

First, let's explore the waveform monitor. To many editors and colorists, the waveform monitor is simply a way to look at the luma or brightness of the video signal, but it can also display the chrominance levels of the signal as well. This chrominance information can be used to minimize color casts in your images. One of the most basic uses of the waveform monitor is to allow you to see that your luma and setup levels are legal. This means that the brightest part of the luma signal does not extend beyond the 100% mark — with occasional specular highlights allowed to reach 105%, more or less, depending on the individual broadcaster's specs — and that the darkest part of the picture does not drop below 0%

For composite NTSC video, the 100% level is equivalent to 100IRE with black level at 7.5IRE mark for NTSC video with setup or 0IRE for NTSC video without setup. So how do you know if your video should be with or without setup? Well, with virtually all analog NTSC video, you need to have setup with blacks at 7.5IRE. However, no digital format has setup. From DV to HDCAM, setup is not used anywhere in the world. In analog formats, only the United States still uses setup (broadcast specification RS170A). NTSC in other parts of the world may or may not have setup. PAL and SECAM do not use setup. Component analog video has different standards also. The SMPTE/EBU (N10) standard does not have setup and typical voltage levels range from 700mv for 100% to 0mv for 0%.. So what do you do if you have a digital VTR and are using the analog in/out connectors? You need to know what standards are being used by the other analog machines. Then match the In/Out settings for Add/Remove Setup to match the rest of the system. Allowing your video to extend outside of the range defined by whatever form of video you are using can cause broadcasters to refuse to air your finished tape until corrections are made or for dubs to have quality issues, like sparkling, bleeding, bearding, and buzzing. Sometimes, if video levels are far enough astray, they can even cause buzzing in the audio channels. There are also legal chrominance levels and other technical specifications regarding timing of the signals and other signal amplitudes and relationships. These all vary slightly from broadcaster to broadcaster. But let's leave this technical stuff aside and concentrate on how to use the waveform monitor for the fun stuff.

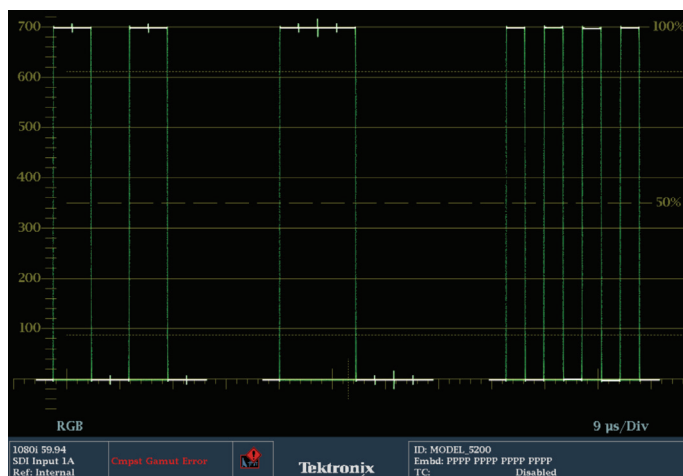


Figure 1-4. Example of an RGB Parade waveform display with 100% color bar signal.

Using a Waveform Monitor to Determine Color Balance

Color balance is indicated by the relative strength of each color channel. With neutral (pure black, white and gray) colors, the strength of each color channel should, technically, be equal. The usual goal of color balancing is to achieve an image where neutral colors are represented without one channel being stronger than another. When color neutrality is achieved, the signal is said to be “balanced.”

The most common reason for unbalanced colors is usually related to how the camera is white balanced on location. For example, if a camera is set up to record in tungsten light when it is actually capturing a scene lit with daylight, the blue channel will be stronger than the red and green channels. Also, some camera sensors have a natural tendency to be more sensitive to certain colors in certain tonal ranges.

These errors, in sensitivity or white balance, can be corrected by monitoring the image with a waveform monitor and making adjustments to the signal until the signal strength of all three channels (red, green and blue) is equal when displaying a neutral color, like pure black, white or gray.

Color balance can also be intentionally misbalanced for artistic purposes, for example, increasing the strength of the red channel, or red and yellow channels to create the impression of a warm, “golden hour” scene.

Two types of waveform displays to look at are both defined as “parade” displays because they show you different channels of information in a “parade” one after the next from left to right. The most common method is the RGB Parade, which shows the red, green, and blue channels of color information horizontally across the display (see Figure 1-4). The reference marks are referred to as the graticule. On a waveform monitor,

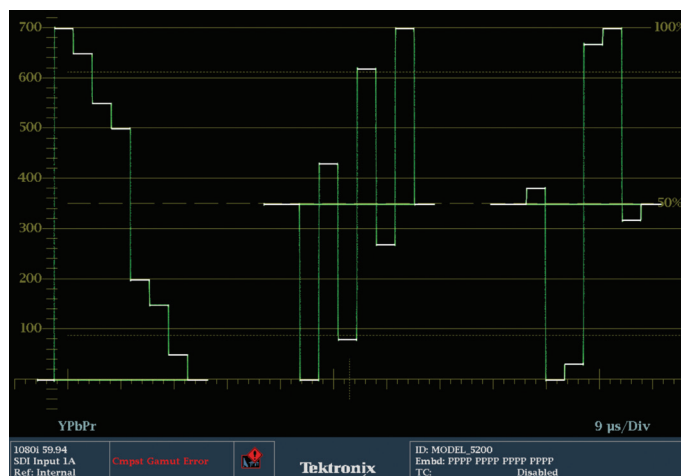


Figure 1-5. Example of an YPbPr Parade waveform display.

these are most obviously the horizontal lines describing the millivolts, IRE or percentages from black to full power (white). Component video levels are represented in terms of millivolts with black being set at 0mV and white at 700mv. This range of video levels is also represented in terms of a percentage scale with 0% equal to 0mv and 100% equal to 700mv. The scale on the waveform display typically has a millivolt scale on the left hand side and a percentage scale on the right-hand side. Within the Tektronix scopes, the user can also select a percentage scale within the Config menu under Graticules & Readouts. If you chose SDI Waveform Graticule to be Percent, then the left hand side of the graticule will show a percentage scale from 0 to 100 graduated in 10% steps.

You can also look at a YPbPr parade waveform, which shows the luma information in the first “cell” followed by the blue difference channel and the red difference channel (Figure 1-5).

This is the way component video is often encoded for video: The luma is sampled, then the color information is created by sampling the difference between the blue signal and the luma (Pb) and the red signal and luma (Pr). It is fairly difficult to ascertain what is wrong with the picture from this type of parade. This display is also sometimes called a YCbCr display. The first cell shows the luma, the second shows that the blue channel is higher than the center line, which indicates the difference in strength from the luma channel. The third cell shows that the red difference channel is lower than the center line, indicating that red is lower than luma. If you want to use this display to balance the blue cast, the goal would be to bring the Pb channel down

Note: For component video you may sometime see YPbPr and other times see YCbCr in reference to component video. Typically YPbPr denotes the analog component signal and YCbCr represents the same signal within the digital domain.



Figure 1-6. The graticule is the part colored gold and the trace is colored green. The colors of the graticule and trace are user selectable. These are the defaults. Many colorists prefer to use white or gray only to keep their eyes from being affected by the saturation of the colors.

The Vectorscope

Whereas a waveform monitor normally displays a plot of signal vs. time, a vectorscope (Figure 1-6) is an XY plot of color (hue) as an angular component of a polar display, much like some familiar color wheels used in color graphics, with the signal amplitude represented by the distance from the center (black).

On a vectorscope graticule there are color targets and other markings that provide a reference as to which vector, or position, a specific color is in.

The signal being monitored generates the trace on the waveform, vectorscope or gamut display. This trace is the representation of the signal itself, often seen in live video as moving, squiggly green lines, though many colorists prefer to change the settings in the waveform monitor so that the trace is viewed as white lines instead.

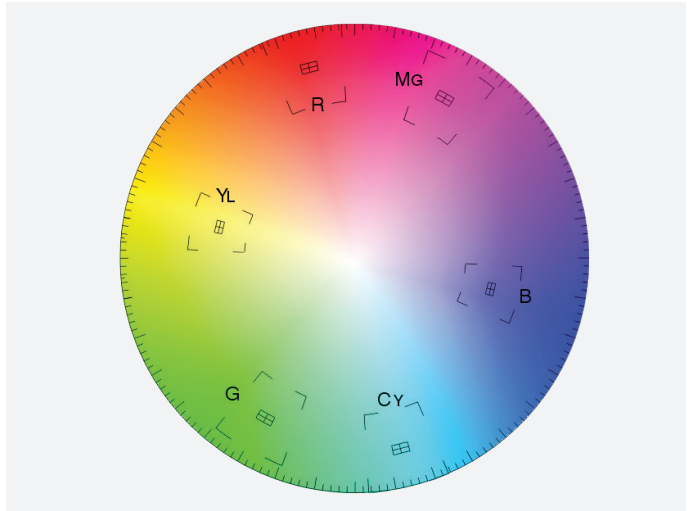


Figure 1-7. The graticule of a vectorscope superimposed with a color wheel.

In color grading applications, the vectorscope helps analyze hue and chroma levels, keeping colors legal and helping to eliminate unwanted color casts. With the gain, setup, and gamma corrections done while monitoring primarily the waveform monitor, the colorist's attention focuses more on the vectorscope for the hue and chroma work. The chroma strength of the signal is indicated by its distance from the center of the vectorscope. The closer the trace is to the outer edge of the vectorscope, the greater the chrominance or the more vivid the color. The hue of the image is indicated by its rotational position around the circle. The easiest way to imagine these relationships is to picture a color wheel superimposed over the face of the vectorscope as in Figure 1-7.



Figure 1–8. Color bar signal to the vector display.

One of the important relationships to understand is the position of the various colors around the periphery of the vectorscope (see Figure 1-7). The targets for red, blue, and green form a triangle. In between each of these primary colors are the colors formed by mixing those primaries. So the color between red and blue is magenta. The color between blue and green is cyan, and the color between red and green is yellow. These secondary colors form another triangle. The other interesting relationship that is formed on the vectorscope is that complementary colors are directly opposite each other. Red is opposite cyan, magenta is opposite green, and yellow is opposite blue. These relationships will play a pivotal role as you begin to manipulate colors. For example, if you are trying to eliminate a magenta cast in an image, a glance at the vectorscope will tell you that you need to add green, which is opposite magenta. Or you could reduce red and blue in equal amounts (the two colors that make magenta). If an image has yellows that are too cyan, then adding red will begin to solve the problem. Eventually, you should not even need the graticule (the graphic part of the vectorscope that identifies color targets) to know where the colors lie on the face of the vectorscope.

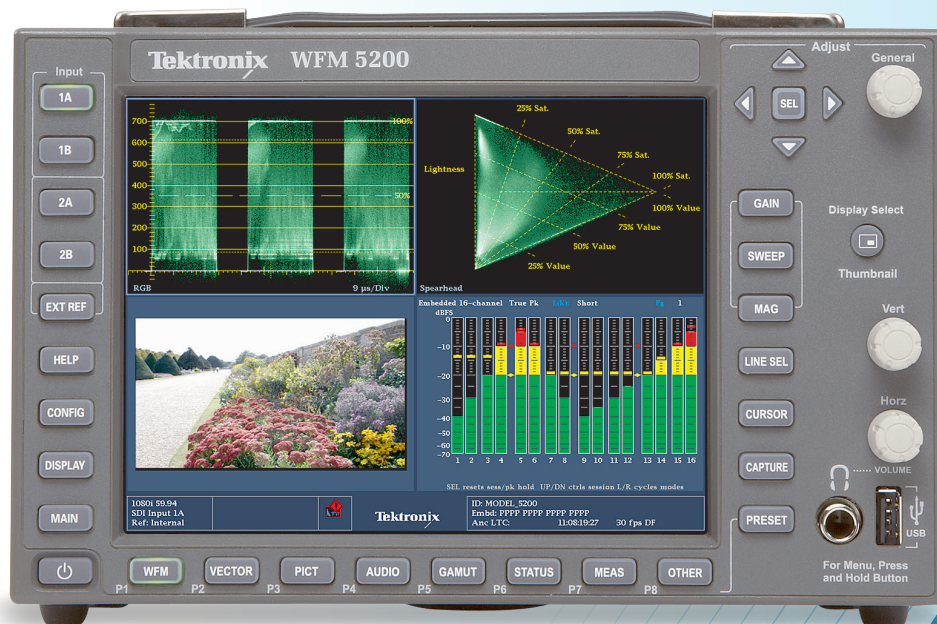
The chroma information presented on the vectorscope is instrumental in trying to eliminate color casts in images. As stated earlier, chroma strength is represented by its distance from the center of the vectorscope. Because white, black, and pure grays are devoid of chroma information, they all should sit neatly in the center of the vectorscope. While most video images will have a range of colors, they also usually have some amount of whites, blacks, and neutral grays. The key is to be able to see where these parts of the picture sit on the vectorscope and then use the color correction tools at your disposal to move them toward the center of the vectorscope.

Apply a color bar signal to the vector display with White, Yellow, Cyan, Green, Magenta, Red, Blue and Black bars. You can follow this pattern within the vector display (Figure 1-8) starting from the center trace the display to yellow vector (YL) then Cyan (CY) and follow on to Green (G), Magenta (MG), Red (R), Blue (B) and then back to the center of the display.

For nearly all professional colorists, the various waveform displays — Flat, Low Pass, Luma only, RGB Parade, and YCbCr Parade — plus the vectorscope are the main methods for analyzing your image. While experienced colorists often rely on their eyes, they use these scopes to provide an unchanging reference to guide them as they spend hours color correcting. Without them, their eyes and grades would eventually drift off course. Spend time becoming comfortable with these scopes, and knowing what part of the video image corresponds to the images on the scopes.

Section 2:

Overview of Tektronix Displays for Color Grading



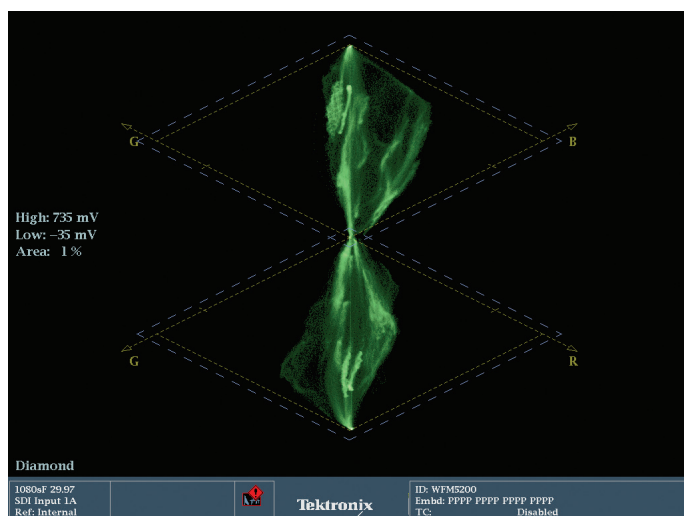


Figure 2-1. Diamond Display.

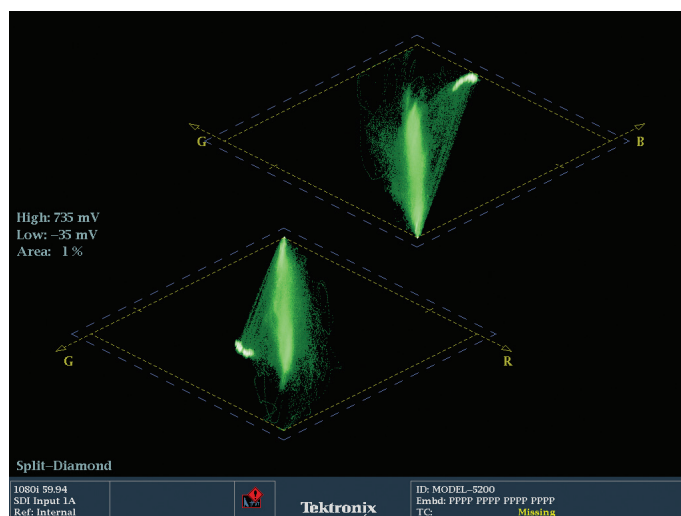


Figure 2-2. Split Diamond Display.

Section 2 Overview of Tektronix Displays for Color Grading

Tektronix has developed several monitoring displays to help identify and resolve gamut violations and to assist with artistic color grading. Some of these displays are relatively new and may appear complex, but they are all designed to provide specific visual representations of color gamut that give easy, immediate visual cues when errors are present once you gain understanding of the concepts and techniques behind these displays that are discussed in this next section. These displays are the Diamond Display (Figure 2-1), Split Diamond (Figure 2-2), Arrowhead (Figure 2-3), Spearhead (Figure 2-4), and Lightning Display (Figure 2-5).

Each of these displays is simply a different interpretation or presentation of the color space. Determining which of these presentations is most helpful is sometimes simply a matter of personal preference and sometimes a matter of knowing the intended use and signal path of the video.

For example, Tektronix's Arrowhead display was developed because component digital signals may still be transcoded and transmitted as a composite signal in local broadcast markets. This conversion to composite could require monitoring the transcoded signal with a separate composite analog waveform monitor, but Tektronix created the Arrowhead display to allow engineers and operators to easily see out-of-gamut conditions in composite color space without requiring a composite encoder and separate composite waveform monitor.

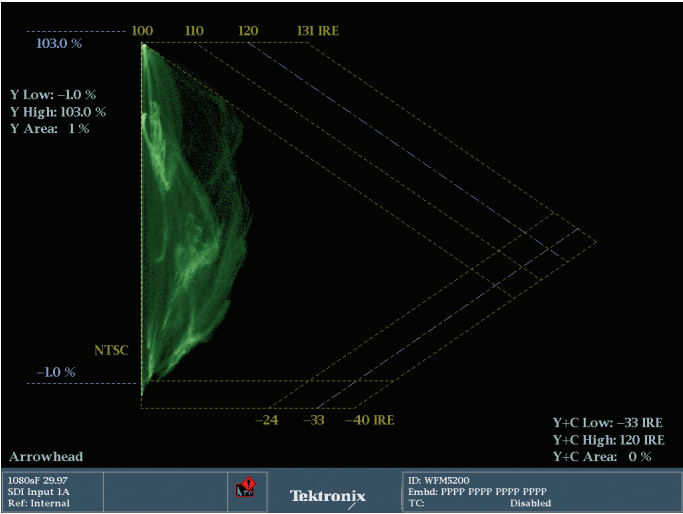


Figure 2-3. Arrowhead Display.

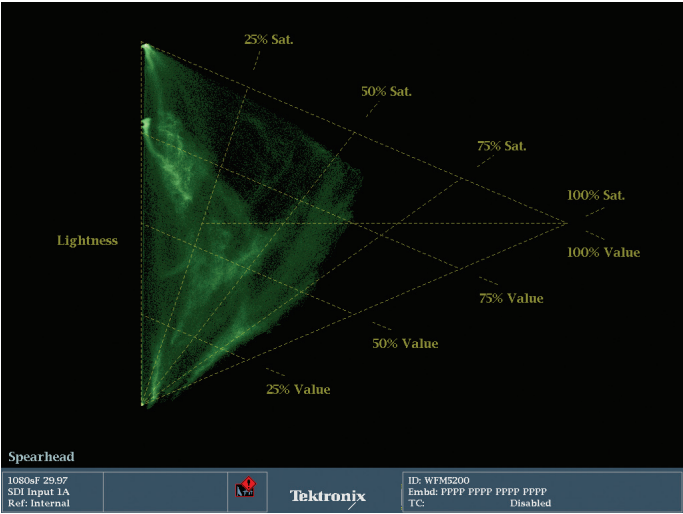


Figure 2-4. Spearhead Display.

COLOR GRADING AND GAMUT MONITORING WITH THE DIAMOND DISPLAY

The Diamond and Split Diamond displays were developed to assist in visualizing the interaction of RGB signals (Figure 2-1 and 2-2 respectively) and are intuitive indicators of both R'G'B' gamut violations and the “balance” of the signal, providing immediate feedback when an image has a color cast.

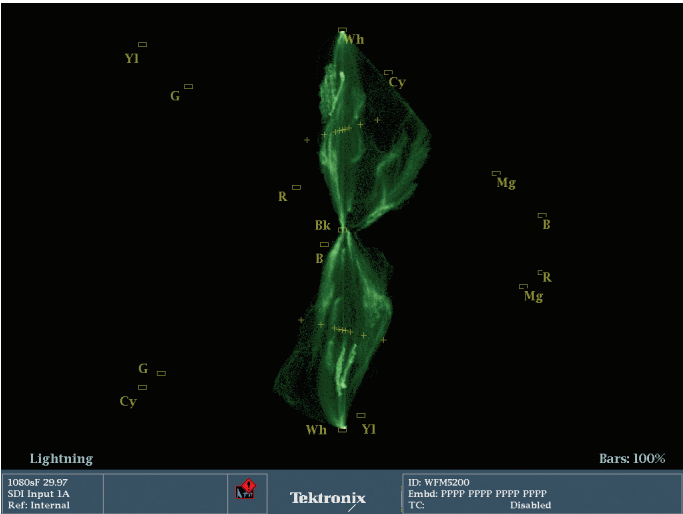


Figure 2-5. Lightning Display.

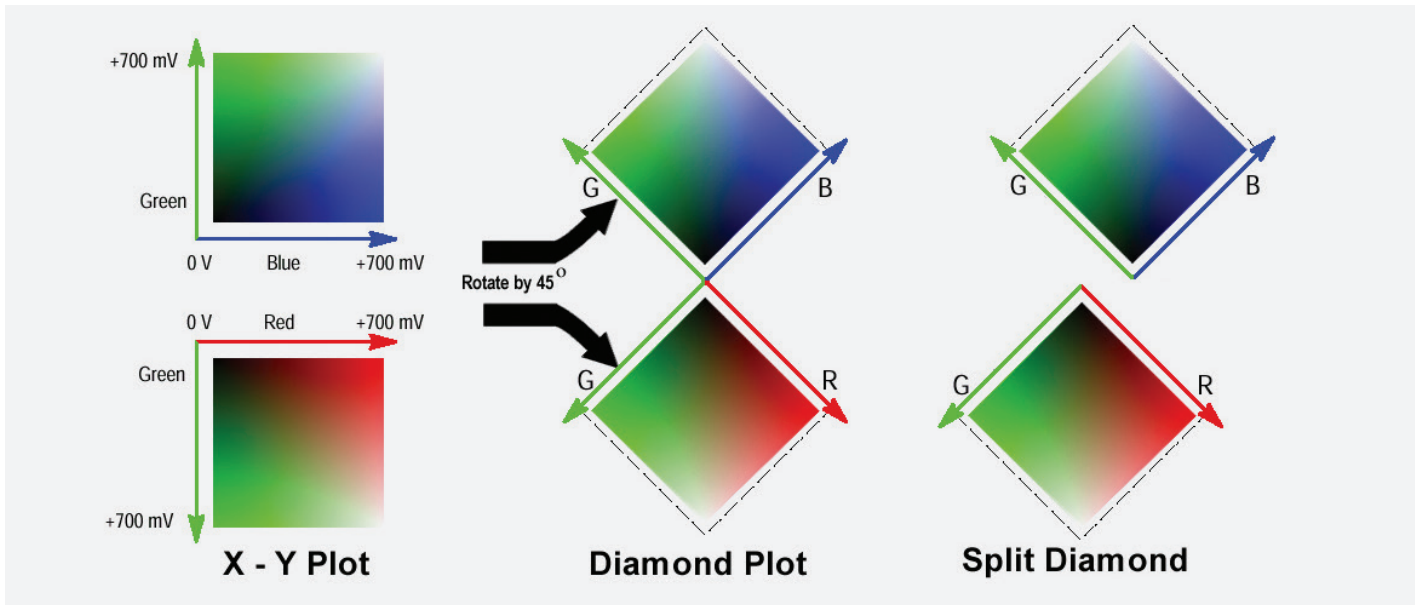


Figure 2-6. Construction of a Diamond Display.

The Diamond display is the most reliable and useful R'G'B' gamut violation indicator available for several reasons. Because the top diamond in the Diamond display indicates levels of blue and green signal components, while the bottom diamond displays only red and green, it is easy to identify which channel or channels are in error when manipulating the R'G'B' signal (Figure 2-6 and 2-7). And, with the green signal indicated on the left side of both diamonds, the ability to identify errors in specific channels is made even easier.

Another important advantage of the Diamond display is its ability to be used as a subjective measure of the severity of a gamut violation. Instead of the simple “on/off” or “yes/no” violation displays of some gamut indicators, the Diamond Display presents the user with a simple visual display that shows not only the specific location of an error, but the severity of that error. The distance that the trace extends beyond the diamonds provides great visual feedback about the importance or severity of the violation.

The Diamond Display indicates pure black where the two diamonds join in the center of the display. If the black is too light (milky) then the trace starts above the bottom of the top Diamond and below the top of the bottom diamond. If there is a color cast to the black, that cast is represented with the trace swinging to the left or right of the diamonds.

A perfectly monochromatic (i.e. black and white) signal of the full contrast range or voltage range of video will display as a perfect vertical line. This line extends from the absolute center of the two diamonds, vertically to the top of the top diamond

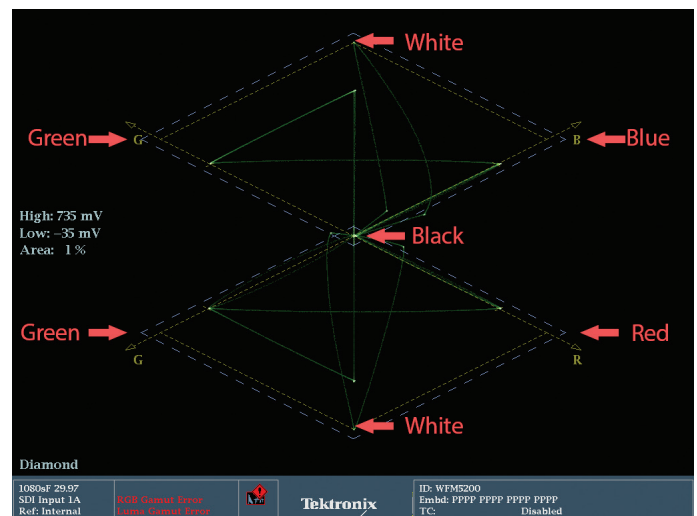


Figure 2-7. Diamond display explained.

and the bottom of the bottom diamond, forming a perfect straight line up the middle of the diamonds.

Monochromatic images are rare in modern broadcasting, but even full color images that are properly balanced usually show a good balance through the middle of the two diamonds, with nearly equal amounts of the trace extending away in all four quadrants of the diamonds.

As for gamut, the Diamond Display clearly indicates any gamut violations by any portion of the trace that extends outside the boundaries of one or both of the two diamonds. Again, to see gamut violations in the black areas, it is helpful to switch over to the Split Diamond Display. But it is easier to see the “balance” of the image in the standard Diamond Display.

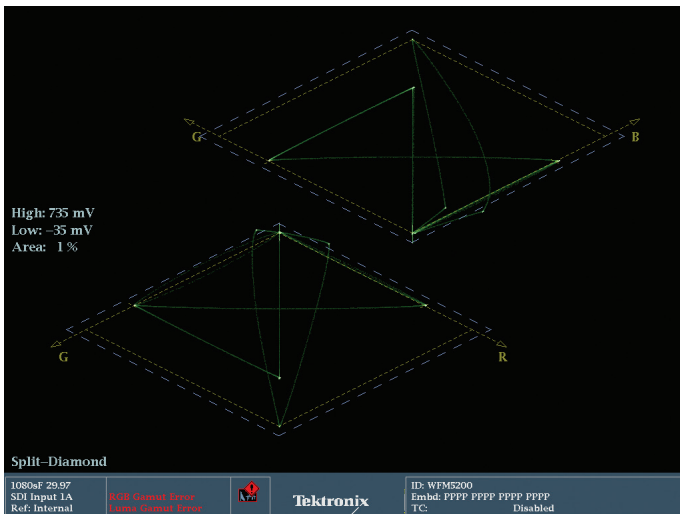


Figure 2-8. The Split Diamond is the same as the Diamond display, but it offsets the two Diamonds to either side to make it easier to see the trace near black.

If blacks are too low, it is difficult to see on the Diamond Display, which is why the Split Diamond was designed. The Split Diamond is essentially the same display as the Diamond, but the two diamonds are off-set slightly, left and right, so that the exact position of the trace in the black areas is easier to see (Figure 2-8).

In the Diamond and Split Diamond Display, pure white is indicated by a trace at the center top of the top diamond and the center bottom of the bottom diamond (Figure 2-11). If white is not at full voltage (power or brightness), then the trace will fall short of reaching the top of the top diamond and the bottom of the bottom diamond (Figure 2-10).

If there is a color cast to the “white” signal, the trace will skew off to left or the right at the top of the top diamond and the bottom of the bottom diamond.

Pure gray is indicated in the center of the broadest part of both diamonds. If there is a color cast in the mid-tones or gammas, the trace will skew off to the left or the right across the breadth of either or both of the diamonds (Figure 2-12).

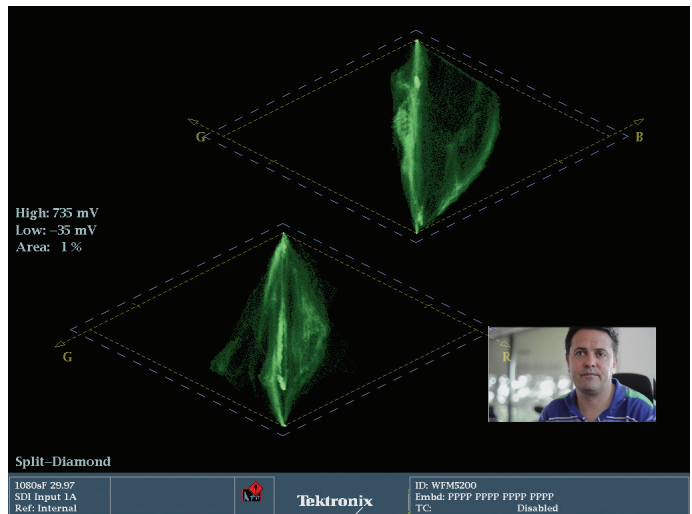


Figure 2-9. This shows a Split Diamond with a well-balanced video image. (Note the thumbnail of the video image in the bottom right corner). Most of the trace is centered horizontally. The trace also extends to the full vertical extension of the diamonds, indicating proper exposure.

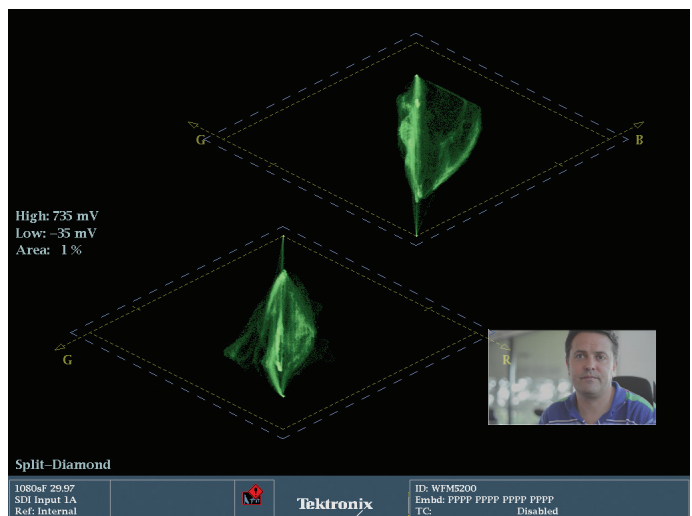


Figure 2-10. This shows the Split Diamond with the same image as in Figure 2-9, but the gain has been lowered and the shadows have been lifted or brightened. Notice that the trace no longer extends to the top or bottom of either diamond. With the trace moved away from the center, it indicates the lifted or lightened blacks. With the trace moved away from the top of the top diamond and the bottom of the bottom diamond, it indicates the lowered gain.

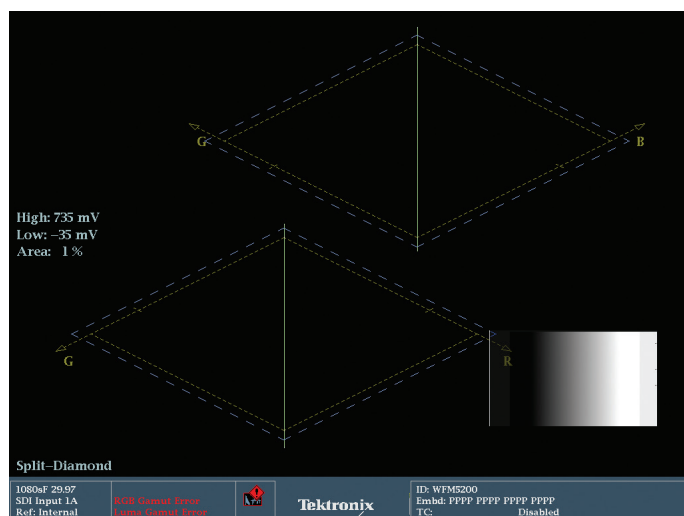


Figure 2-11. This shows the Split Diamond displaying a black to white “ramp” test signal. The signal is monochromatic, extending from pure black to pure white. The trace extends in a perfect, straight line through the middle of the diamonds.

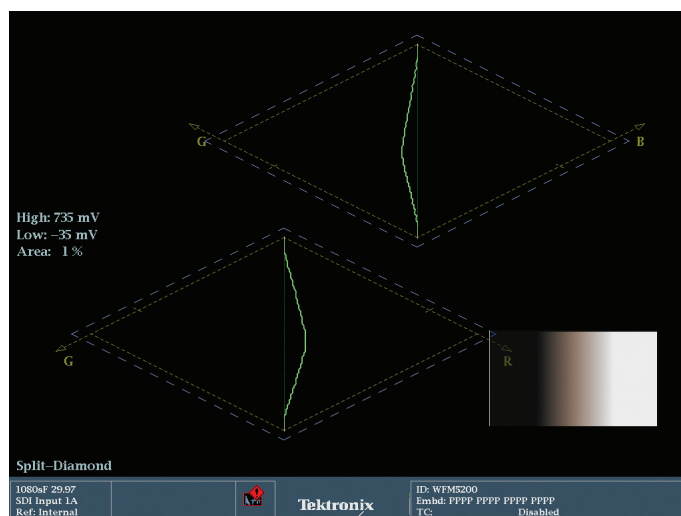


Figure 2-12. This image shows the Split Diamond displaying the same black to white “ramp” test signal as in Figure 2-11, except the mid-tones of the image have been warmed, pushed towards a reddish yellow. This cast is indicated by the trace skewing towards the green side of the top diamond and the red side of the bottom diamond in the middle of the diamonds. The middle of the diamonds indicates the mid-tones. The trace moving towards red makes sense. The trace moving towards green in the blue/green diamond indicates the yellowish cast which is the opposite of blue and includes both red and green.

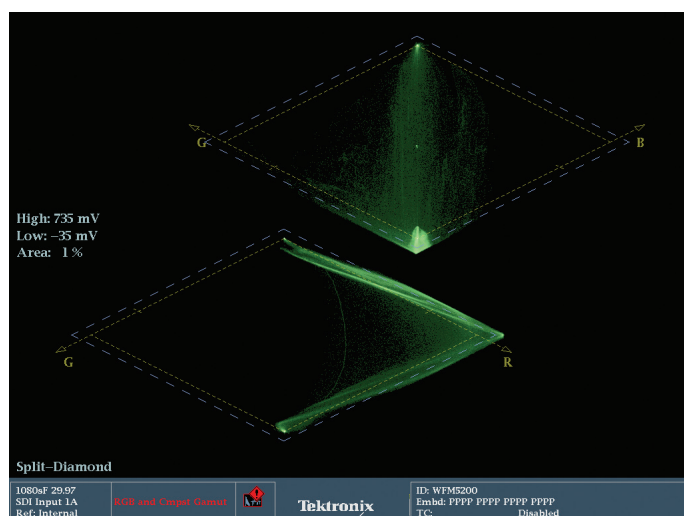


Figure 2-13. This shows the Split Diamond displaying a trace for an image that has been pushed far towards red in the mid-tones causing a Gamut error. The trace is clearly outside the diamonds, indicating the illegal gamut levels.

In creative and operational environments where monitoring R'G'B' gamut limits is critical, the Diamond display provides the greatest information in the most intuitive display.

Conventional waveform monitor display modes, such as parade and overlay, are great for measuring signal levels, but gamut limit violations don't stand out like they do on a Diamond display. The specific component causing the error can be determined with the Diamond display (Figure 2-13).

Signal monitoring in the R'G'B' color space does have several very important applications. Even though signal transmission in R'G'B' is rare, many creative and operational controls continue to bear the labels R', G' and B'. Computer graphics workstations, camera painting systems and color grading applications operate in the R'G'B' color space and all of them can easily be adjusted to create illegal gamut. Monitoring these types of systems is an obvious application for the Diamond display. Diamond excels in several areas for R'G'B' gamut, however it is not the answer to every measurement question. Other color spaces, such as composite, require different displays and measurement techniques.

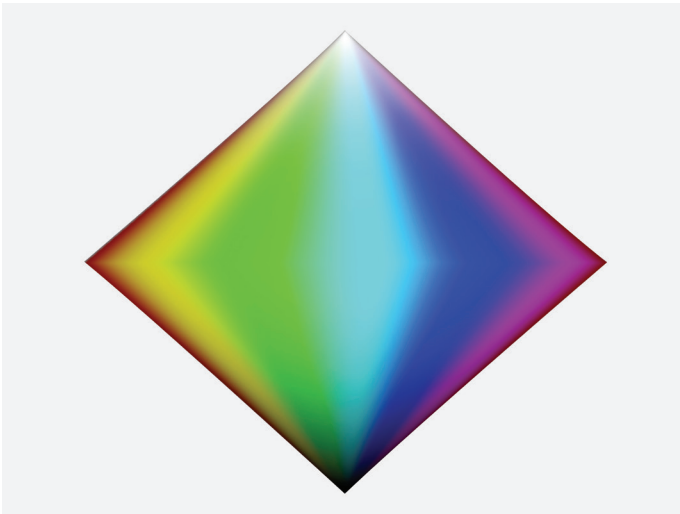


Figure 2-14. Color cones – side view.

COLOR GRADING WITH THE SPEARHEAD DISPLAY

The newest gamut display from Tektronix is the Spearhead display, which shows the artistic metrics of color saturation and color value or lightness combined with RGB gamut limits. To fit Spearhead into the concept of color space, let's return to the color cones. If you collapse the diamond on its vertical axis to be a triangle, then that view of the color space is represented by the Spearhead (Figure 2-14).

The Spearhead is essentially a compressed, “folded” view of the Diamond display. If you take the bottom green/red diamond and fold it up vertically over the green/blue diamond, you have a single diamond with green on the left and red/blue on the right, with black at the bottom and white at the top. Then fold the green side of the diamond horizontally over the red/blue side, with the fold along the black to white axis of the diamond. Now you have a triangle with black at the bottom, white at the top and saturation on the horizontal axis (Figure 2-15).

This allows a colorist to adjust live video signals in the HSV (Hue, Saturation, Value) space within the valid signal gamut range. The Spearhead display is constructed by plotting the maximum of the R', G', and B' color values for each sample versus the minimum of the three values. The resulting area is a triangle that represents the full RGB color gamut. This triangle represents Lightness with black at the bottom left corner of the triangle and white at the top left corner. The horizontal axis represents chroma increasing from left to right. Value increases up from the bottom, extending towards the right and Saturation extends from the top towards the right.

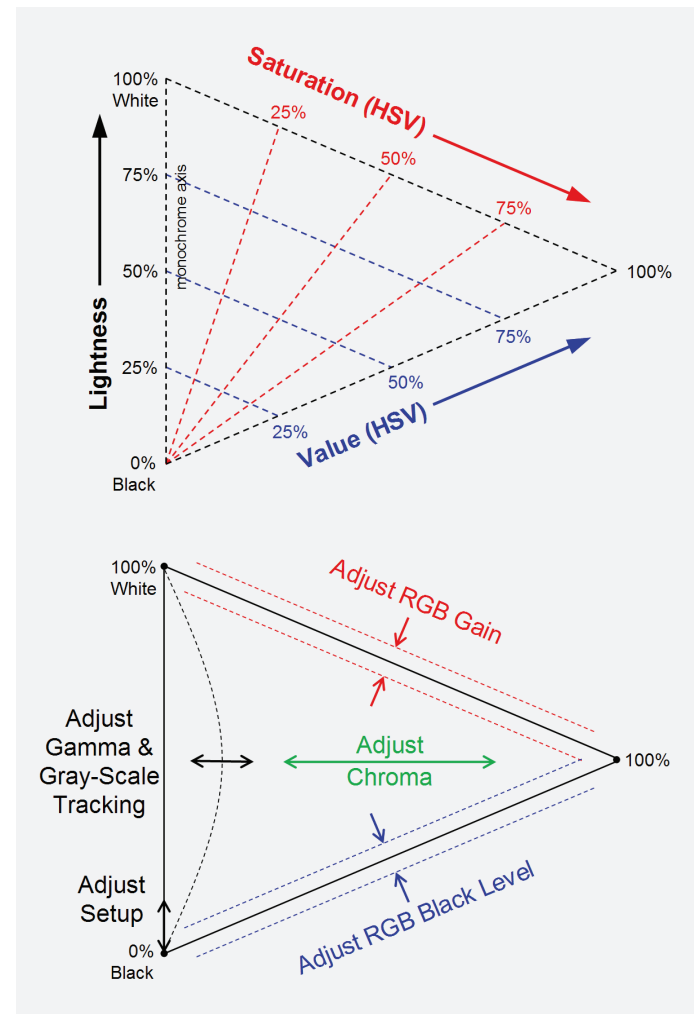


Figure 2-15. Constructing the Spearhead diagram.

The Spearhead is a unique display because it represents both luminance and saturation values in a single display. Normally, luminance values are displayed on a waveform monitor and saturation is displayed on a vectorscope. So the vectorscope and Spearhead together show two orthogonal views of three-dimensional color space.

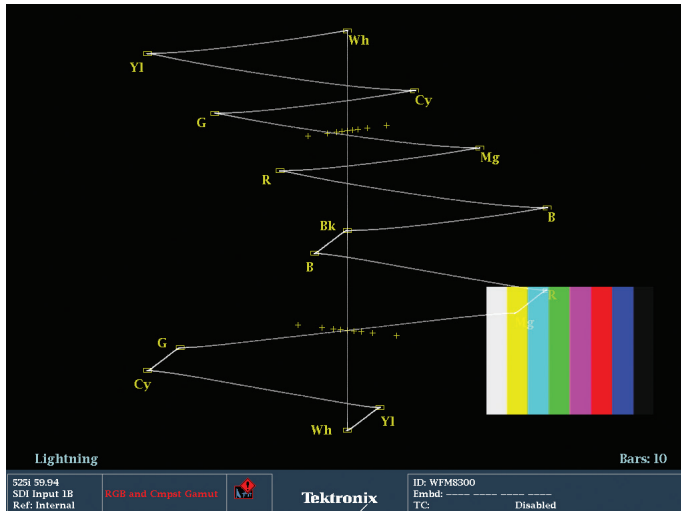


Figure 2-16. The Lightning display.

YPBPR COMPONENT MONITORING WITH LIGHTNING DISPLAY

The Lightning display (Figure 2-16) facilitates quick alignment of component color bar signals to ensure correct amplitude and timing of the signal. A traditional vector display only shows the two color difference components, whereas the Lightning display shows the luma and color difference components. The Lightning Display is not intuitive for use in creative or artistic uses, but has value to the engineering department when monitoring color difference signals.

Often, operators and engineers want to monitor and adjust levels on the component signal. Many users are familiar with making these adjustments with a composite signal using a waveform monitor and vectorscope. Tektronix developed the Lightning display to simplify the task of making these adjustments within the component domain, using just one display.

The Lightning display also offers inter-channel timing information by looking at the green/magenta transitions. When the green and magenta vector dots are in their boxes, the transition should intercept the center crosshair in the line of nine timing marks. Therefore the Lightning display offers a simple means for checking luma and color difference signal amplitudes and inter-channel timing — all in one display using a standard color bars test signal.

The Lightning display is generated by plotting luma versus $P'b$ in the upper half of the screen, and inverted luma versus $P'r$ in the lower half — like two vector displays sharing the same screen. The bright dot at the center of the screen is blanking level (signal zero). Increasing luma is plotted upward in the upper half of the screen and downward in the lower half of the display. If luma gain is too high, the plot will be stretched vertically. If $P'r$ gain is too high, the bottom half of the plot will be stretched horizontally. If $P'b$ gain is too high, the top half of the display will be stretched horizontally.

If the color-difference signal is not coincident with luma, the transitions between color dots will bend. The amount of bending represents the relative signal delay between the luma and color-difference signals. The upper half of the display measures the $P'b$ to Y' timing, while the bottom half measures the $P'r$ to Y' timing. If the transition bends outward toward white, the color difference signal is leading the luma signal. If the transition bends inward toward the vertical center of the black region, the color-difference signal is delayed with respect to luma.

If color bars are at the header of a tape leader the editor can use the lightning display to ensure the amplitude is at the correct level, or make adjustment of the video and chroma levels until all the dots are in the boxes. Then the editor can ingest the material knowing he has compensated for any variety between tape machines.

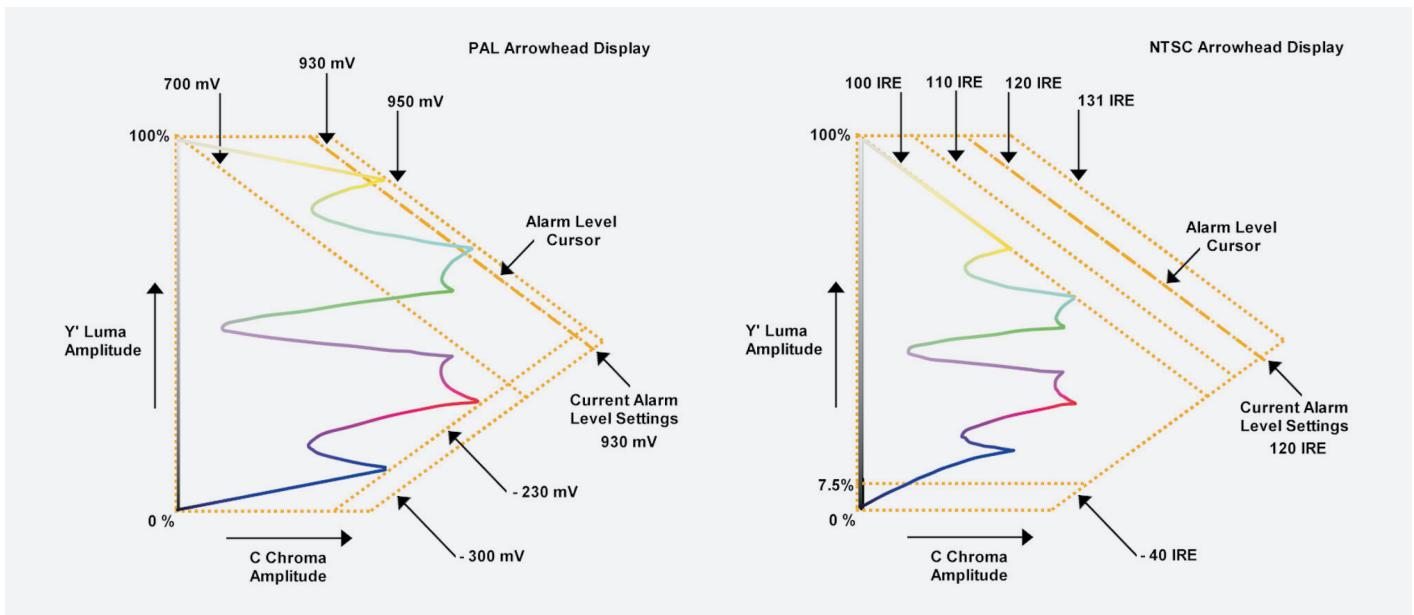


Figure 2-17. Constructing the Arrowhead display.

GAMUT/AMPLITUDE MONITORING WITH THE ARROWHEAD DISPLAY

The Arrowhead display can be used on component signals to determine if the signal is within gamut for a composite PAL or NTSC signal, without the need to process the signal through a composite encoder (Figure 2-17).

COMPOSITE COLOR SPACE

The greatest concern over modern color gamut is in R'G'B'. That is because most applications edit and create in either R'G'B' or Y'Cb'Cr (color difference) or translate and transcode between the two. However, program material may still be transmitted as a composite signal in a hybrid facility or for distribution in local markets. The requirements are different for keeping this signal legal.

Normally, the component signal is applied to a composite encoder. The composite signal is then measured and monitored using a familiar analog waveform monitor and vectorscope. Tektronix developed the Arrowhead display to allow engineers and operators to easily see out-of-gamut conditions in composite color space without requiring a composite encoder.

The Arrowhead is similar in basic structure to the Spearhead but illustrates composite color gamut. The artistic use of Arrowhead is limited, but it is essential to the technical monitoring of the composite signal.

The Arrowhead display plots luma on the vertical axis, with blanking at the lower left corner of the arrow. The magnitude of the chroma subcarrier at each luma level is plotted on the horizontal axis, with zero subcarrier at the left edge of the arrow. The upper sloping line forms a graticule indicating 100% color bars total luma + subcarrier amplitudes. The lower sloping graticule indicates a luma + subcarrier extending toward sync tip (maximum transmitter power). The electronic graticule provides a reliable reference to measure what the luminance plus color subcarrier will be when the signal is later encoded into NTSC or PAL. An adjustable modulation depth alarm capability is offered to warn the operator that the composite signal may be approaching a limit. The video operator can now see how the component signal will be handled in a composite transmission system and make any needed gradings in production.

Normally for NTSC transmission the threshold is set at 110 IRE because values over this limit can cause problems at the transmitter. The multi-format nature of Tektronix waveform monitors permits the Arrowhead display to be used not only for standard definition, but also for high definition video signals which maybe downconverted to standard definition for broadcast or distribution.

GAMUT MONITORING CONCLUSION

While virtually all component video transmission occurs in one of the standard color difference formats today, viewing those signals in the R'G'B' color space remains a necessity. As computers become more widely used in video applications, the possibility of creating illegal video signals increases and the Tektronix-exclusive Diamond display is the best tool for keeping track of gamut violations. Performing color grading adjustments, gray scale tracking adjustments, or black balance adjustments are additional tasks that are simplified by the Diamond and Spearhead displays. The Spearhead and the

vectorscope are great complementary displays that provide a full orthogonal view of three-dimensional color space. The Arrowhead display offers a means for the digital hybrid facility to ensure that the R'G'B' signal is valid for transmission in a PAL or NTSC environment, and it keeps the operator's task within the digital domain. For tape alignment, the Lightning display ensures correct amplitude and inter-channel timing of the signal using the familiar color bars test signal. These exclusive Tektronix displays help simplify the tasks that video professionals face in an ever increasing complex environment.

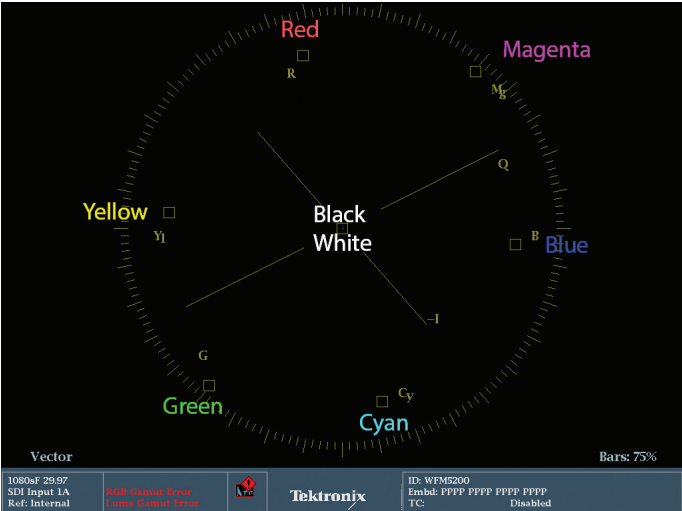


Figure 2-18. Vectorscope showing colors of the targets.

INTRODUCTION TO THE LUMA QUALIFIED VECTORSCOPE

The Luma Qualified Vectorscope (LQV) operates like a regular vectorscope except that the user can filter the signal being displayed on the vectorscope based on a maximum and minimum luma range or, more specifically, voltage.

A traditional vectorscope has no way to display luma values. It simply shows the saturation and hue values. Saturation is represented with less saturation displayed in the center of the vectorscope's circular display, and greater saturation displayed as the trace extends out towards the edges of the circle. The vectorscope also displays the hue of the signal as angles around the circle. Roughly, the red hue is displayed near the top of the vectorscope, blue to the right and green to the left. Specific hues can be more closely determined by looking at the targets for the primary and secondary colors that are displayed on the vectorscope graticule (Figure 2-18).

However, on a vectorscope, it is impossible to tell white from black. Since both are without saturation, both appear superimposed in the center of the vectorscope along with all levels of pure gray.



Figure 2-19. The WFM and WVR 5200 are capable of two trace displays. The other two displays must be non-trace displays, like the Picture monitor, Audio bar and Status displays.

The LQV was designed with the colorist in mind. Virtually all color grading toolsets divide the ability to alter hue and saturation based on specific tonal ranges. Most popular of these tools are the three trackballs or color wheels that provide control over the hue and saturation of the shadows, mid-tones and highlights of the signal. On a traditional vectorscope, these three tonal ranges are overlaid on each other with no way to distinguish the hue and saturation levels of one tonal range compared to any other.

But with Luma Qualified Vectorscopes, the colorist or operator can specifically determine what exact tonal range is displayed. This means that control over the signal using the three trackballs, or any tonal range-based controls, is much easier to see.

To understand the practical nature of this display, it must first be set up according to the preference of the user. Tektronix 7000 and 8000 series waveform monitors and rasterizers can display as many as four “trace” displays at once. The 5200 series can only display two “trace” displays. For the 7000 and 8000 series, it is possible to display three separate Luma Qualified Vectorscope displays - one for each tonal range - and a standard vectorscope display all at once. For the 5200, the most practical combination of displays is to have one Luma Qualified Vectorscope set for the shadows and another set for highlights.

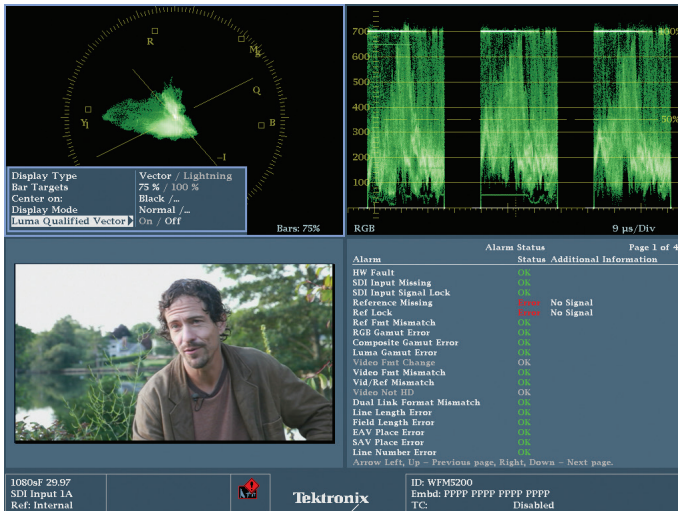


Figure 2-20. Notice the blue selection square around the top quadrant. This shows that the top left quadrant is selected. This selection is done with the Thumbnail or Display Select button.

Set-Up Of A Luma Qualified Vectorscope

To set up this combination on a 5200:

1. Using the thumbnail button to choose one of the four quadrants. Preferably a “trace” display if there are already two “trace displays” on the monitor.
2. Press the **Vector** button to turn that quadrant into a vectorscope display (see Figure 2-21).
3. Hold down the same **Vector** button until a menu appears in the vectorscope quadrant.
4. Set the display type to vector. The bar targets can be set to either 75% or 100%. The “center on” should be set to Black. The display mode should be set to Normal. These are all basically the default settings.
5. To change the Luma Qualified Vector menu option use the “Adjust” down arrows to highlight the Luma Qualified Vector option.
6. Press the **SEL** button or the right arrow key to toggle between the “Off” status and the “On” status for this option.
7. When the status for Luma Qualified Vector is ON, two additional menu choices appear below.
8. Press the down arrow to move to the LUMA HIGH option.
9. Press the right arrow to select the numeric range choice.
10. Use the GENERAL dial to select the top of the range. If you want to have this particular LQV to display highlights, then the default should already be 766.92. If it’s not, then rotate the dial clockwise until the numeric display reaches its maximum.
11. Press the left arrow key to move back to the LUMA HIGH option, then press the down arrow key to move down to the LUMA LOW option.

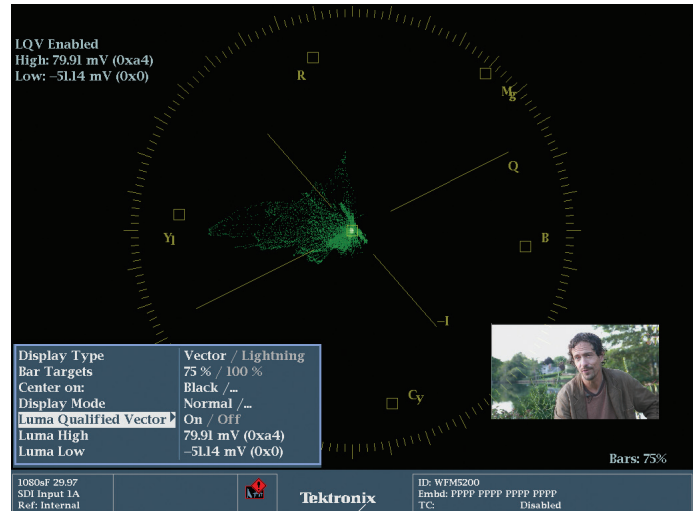


Figure 2-21. The top left quadrant has been called up full frame to better see the menu choices. The Luma High option has been chosen and the General dial is ready to adjust the range.

12. Press the right arrow to select the numeric range choice.
13. Use the **GENERAL** dial to select the bottom of the range.
In this case we've set the top to the upper limit in step 10. Now complete the description of the highlight range by entering a lower limit. These two values will describe the range that this particular LQV will display. The number you choose for this lower limit is one of personal taste. You may want to set a number now and then revise it later when you see how it works. The real range of millivolts is from 0-700, so to describe highlights as the brightest 10% of the image, set the lower level to approximately 630mv. To describe highlights as the brightest 25% of the image set the lower level to 575. To do your own math, turn your percentage to a decimal value (25%=.25, 33%=.33), multiply that decimal value times 700 and subtract that number from 700. So $10\% = .10 \times 700 = 70$. $700 - 70 = 630$. Don't worry about exact values. The control is very granular and the difference between 1 or 2 millivolts won't be noticed (see Figure 2-22).

14. Press the **Vector** button to save your changes.
15. Use the thumbnail button to move to the other trace display or to any other quadrant.
16. Follow steps 2 through 9
17. In steps 1-14 you created an LQV display for highlights (Figure 2-23). To create a similar LQV to display shadows (Figure 2-24), follow the directions in step 10, but change the LUMA HIGH value so that only the lowest 10% (or whatever your chosen level) is displayed. Using the math example in step 13, 70 millivolts is 10%. To set the upper range of your shadow range, add 70 to 0mv. If you prefer 20, set it at 140mv.

18. Use the left arrow to move back to the LUMA HIGH menu choice.
19. Use the down arrow to move down to the LUMA LOW menu choice.
20. Use the right arrow to select the numeric range choice.
21. Use the GENERAL dial, turning counter clockwise, to adjust the level as low as it will go. This level is already probably set to the default of -51.14 mv. If so, there is no need to adjust it (see Figure 2-23).

22. Press the VECTOR button to save your changes.

Notice that the two quadrants that you just created look identical except that each has a small text overlay that says "LQV Enabled" and below that it shows the range of luminance values that will be displayed. These should be the numbers you just set.



Figure 2-22. The HIGH and LOW Luma Qualified Vectorscopes are set up in the top two quadrants with the highlights on the shadows displayed on the left top quadrant and the shadows displayed on the right top quadrant.

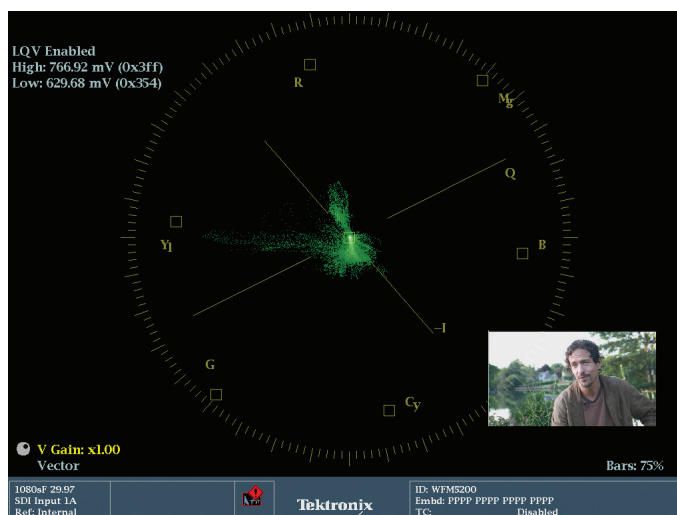


Figure 2-23. LQV Highlight selection.

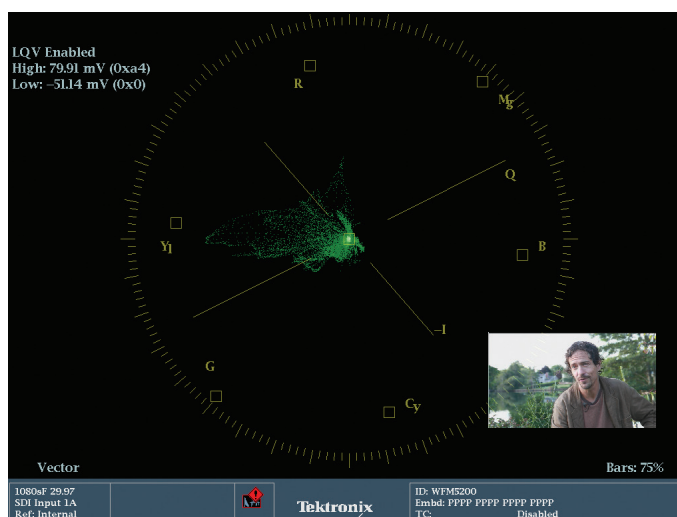


Figure 2-24. LQV Shadow selection.

Saving a Preset

That last setup required a lot of work, so you may want to save this combination of displays as a preset that can be recalled, saved and shared with others. To save this, execute the following steps:

1. Press the **PRESET** button. The bottom buttons will light up and eight “soft” buttons will appear on the display screen along the bottom. Each of these soft buttons may have a name already assigned, or they could all read “<empty>” if your unit has come straight from the factory.
2. To save your preset (the two LQVs plus whatever the other two quadrants are set to), hold down one of the lit buttons at the bottom, corresponding to one of the “soft buttons” on the screen. (WARNING: If there is already a preset on the soft button you choose, it will erase that preset!)
3. A dialog will appear on screen: “Save Preset #x” Continue will overwrite existing preset. Select Continue to proceed or Cancel to abort. To save your preset, use the right arrow key to highlight the Continue button in yellow and press the SEL button to execute the choice. A dialog will appear confirming that you have saved the preset.
4. The default name of that preset is probably “A1.” To choose a more descriptive name for your preset, follow the following steps.

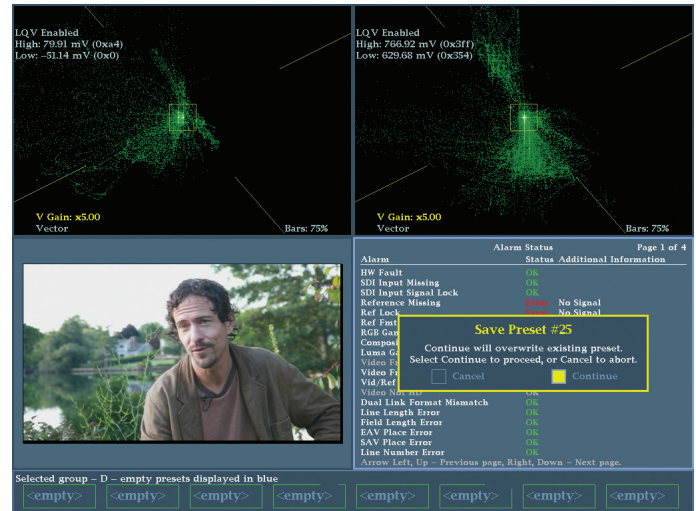


Figure 2-25. This preset is being saved to bank D1. You can save to any empty or unwanted bank of presets.

1. Hold down the preset button for 2 seconds, or until a dialog box appears at the bottom screen including the menu choice “Save Preset.”
2. Use the down arrow key to select the menu option, “Rename Preset.”
3. Press the right arrow twice to navigate over to the menu choice “Rename Group A.”
4. Use the down arrow key to select the menu option “A1” or whatever your newly created preset was called.
5. Press the right arrow. A new dialog will appear called “Rename Preset.” Below, are eight boxes. The first two boxes may have the letters A1 in them.
6. To change the name of the preset, press the right arrow key three times to navigate past Cancel, Clear, and Accept, moving the highlight to the first box.
7. Use the General dial to scroll through the capital letters, numbers, symbols, space, lowercase letters, numbers, symbols and space choices. To call this preset simply LQV, use the General dial to scroll to the capital letter L.

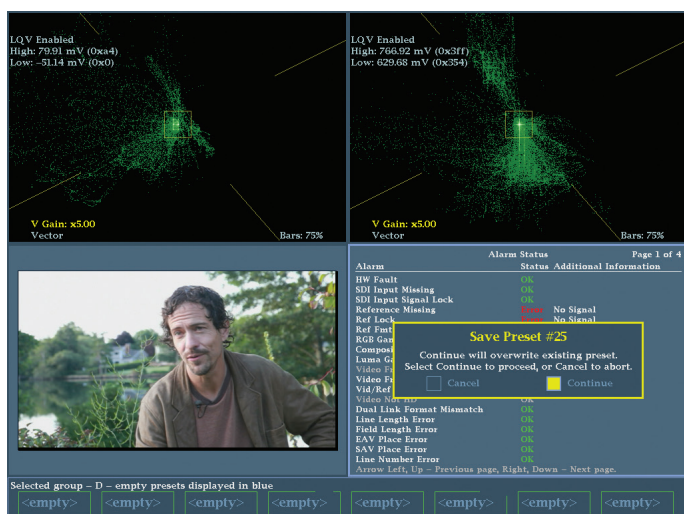


Figure 2-26. This menu shows the results of Steps 1-7. The selection is on Cancel. Pressing the right arrow will move through the Clear and Accept options and then up to the individual letters. Once the yellow selection cursor is in the box of the letter you want to change, use the General dial to cycle through the alphanumeric selections, using the right arrow to move to the next letter box. To save, use the right arrow to move the yellow selection cursor in the Accept box.

1. Use the right arrow key to advance to the next box in the Rename dialog.
2. Use the General dial to scroll to the capital letter Q.
3. Use the right arrow key to advance to the next box in the Rename dialog.
4. Use the General dial to scroll to the capital letter V.
5. To save your newly named Preset, press the right arrow key eight times until the highlight appears in the box just to the left of the word Accept in the Rename Preset dialog.
6. Press the enter key to save the Preset.
7. Check your saved preset by pressing the Preset button twice. Once to exit the Preset dialog, and once more to see the Preset soft keys along the bottom. You should see your newly named preset in the soft key above the WFM button.
8. In the future, to recall this preset, simply press the Preset button then the WFM button. If you saved your preset to a position other than the first one, press the corresponding button to the soft key with your desired preset.

Preset Options for Using Luma Qualified Vectorscopes

If you have a Tektronix 7000 or 8000 series, you could create a preset with another LQV display to show the mid-tones. To do this, set the LUMA HIGH value to be the same as the LUMA LOW value of your Highlight LQV and set the LUMA LOW value to be the same as the LUMA HIGH value of your Shadow LQV. You could also set a fourth quadrant to show a standard vectorscope or any other display.

Another variant on this preset for a 5200 would be to have a Shadow LQV beside a regular vectorscope in one preset and another preset with a Highlight LQV beside a regular vectorscope. Then when you are adjusting shadows you can see the effect on just the shadows by calling up your Shadow LQV preset which will show you the effect of your adjustments just in the shadows in your Shadow LQV while at the same time seeing the effect on the entire signal in the standard vectorscope. Then switch presets to the Highlight LQV preset and adjust your highlights while viewing the effect on just the Highlight LQV display while at the same time seeing the effect on the entire signal in the standard vectorscope.

Another variant would be swapping the standard vectorscopes in the presets with Diamond displays so you could monitor whether your adjustments were causing gamut errors.

Note: A Preset saves the configuration of the instrument and also remembers the configuration of each measurement for each tile. Therefore you could configure a variety of different display for each of the tiles, so that when the measurement button is selected for that tile a different display is configured.



Figure 2-27. LQV Highlights and shadows. One possible LQV display configuration with one LQV for highlights and one LQV for shadows.



Figure 2-28. A second possible LQV display configuration with one LQV for shadows and one with a standard vectorscope.



Figure 2-29. A third possible LQV display configuration with one LQV for highlights and one with a standard vectorscope.



Figure 2-30. A fourth possible LQV display configuration with one LQV for shadows (or highlights) paired with a Diamond Display to monitor gamut violations.

Color Grading Using Luma Qualified Vectorscopes

Numerous presets using Luma Qualified Vectorscopes are possible. For the following section on using Luma Qualified Vectorscopes, we'll use the original example of two side by side Luma Qualified Vectorscopes: One set to display the brightest 10% of the signal and one set to display the darkest 10% of the signal. This is the preset we created in the previous section Figure LQVSETup,.)

When using vectorscope displays, whether standard vectorscopes or LQVs, the most intuitive color grading control to use is the color wheel. With a hardware control surface (like the DaVinci Resolve, or Tangent Devices WAVE or ELEMENT, or Avid MC Color), this means using the three trackballs related to shadows, mid-tones and highlights. Avid software uses the term Hue Offsets to describe these color wheels.

The shadow trackball or shadow color wheel should have a very good correlation to the Luma Qualified Vectorscope that you've created with a range from about -51.14mv to 70mv. To balance the color of your shadows, the trace in the Shadow LQV should be centered on the middle target.

TIP: To get a better view of this center region on your LQV or regular vectorscope, you can press the GAIN button to zoom in. The default zoom is 2x. If you hold down the GAIN button for 2 seconds, a dialog appears allowing you to change the 2x option to 5x or 10x. Experiment with how much gain (zoom) helps you get the most accurate results quickest. Press the GAIN button again to exit the menu options.

Using the shadow trackball or shadow color wheel, try to "aim" the trace into the center of the LQV set to display shadows. The direction you move the trackball or cursor in the color wheel should correspond directly with the movement of the trace in the vectorscope or LQV.

Then, using the highlight trackball or highlight color wheel, try to "aim" the trace into the center of the LQV set to display highlights.

This method of color balancing has been used by colorists for decades using a standard vectorscope, but the ability to concentrate on a specific luma range makes balancing the two separate luma ranges much easier and more intuitive.

With your shadows and highlights color balanced, you can use the mid-tone (gamma) trackball or color wheel while monitoring a standard vectorscope or a LQV setup for mid-tones to balance your mid-tones. With your shadows and highlights dialed in properly, mid-tones can also be adjusted to taste using your picture monitor.

With a complex image with a lot of chroma and mid-tone values, you'll quickly see the value of Tektronix's exclusive Luma Qualified Vectorscopes.

Color Grading with the Diamond Display

Most seasoned professional colorists prefer the RGB Parade waveform monitor for balancing colors and setting levels. For many gradings, it's an excellent choice, but for a single waveform display that gives the most information about the image, Tektronix's Diamond display provides a wider range of information. Using it to make intuitive color grading decisions takes a little effort, but is worth the time to learn.

Section 1 of this primer describes the way the Diamond display represents the incoming signal. To recap, black is in the center of the display where the two diamonds join. White is displayed at the top of the top diamond and, less intuitively, also at the bottom of the bottom diamond. Monochromatic tones run straight up the middle of the two diamonds, vertically. Saturation is represented as the trace extends away from that middle axis. The green channel is presented on the left side of both the top and bottom diamonds. The red channel is presented on the right of the bottom diamond and the blue channel is represented on the right of the top diamond. There are letters representing these color channels on each side of the diamonds, so there's no need to memorize these relationships (Figure 2-31).

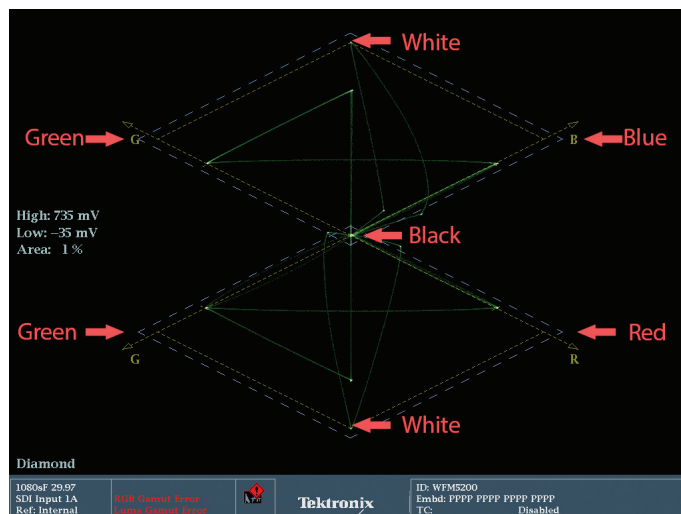


Figure 2-31. Diamond Display explained.

Call up a Diamond display in one of the quadrants of your Tektronix waveform monitor. Bring the Diamond display to full raster. This is done differently on various Tektronix waveform monitors. On the 5200, with the Diamond display quadrant selected, hold down the Thumbnail button. This fills the screen with the Diamond display.

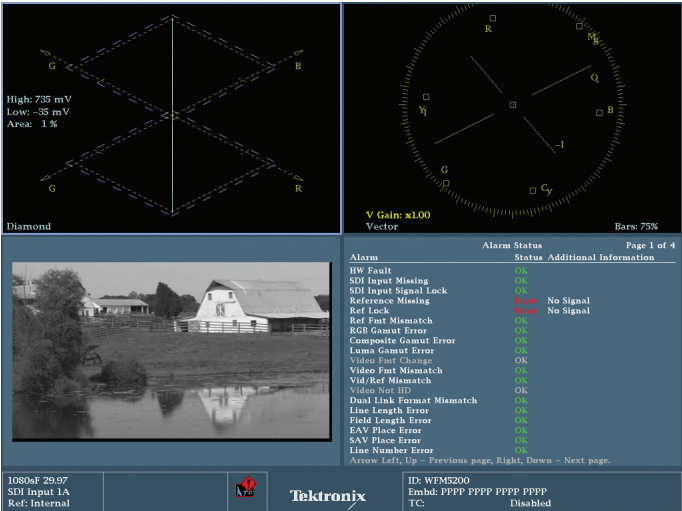


Figure 2-32. Diamond Display showing an image that has had all saturation removed.

To create the display in Figure 2-32, an image was routed from a color corrector to the WFM5200 and all saturation was removed from the image. The Diamond Display shows a fine white line that travels perfectly vertically from the bottom of the bottom diamond up through the center, where the two diamonds meet, and continues all the way to the top of the top diamond.

Using the shadow trackball or color wheel, the shadows were pushed to be as saturated as possible and then we rolled through the various vectors (hues). We monitored these gradings on the Diamond display. With the blacks pushed very green, the trace on the Diamond extends outside of the diamonds to the left (Figure 2-33). This makes sense because the green channel is represented to the left.

Rolling to a perfect blue, the trace extends outside to the right of the top diamond and is straight up and down in the bottom diamond (Figure 2-34).

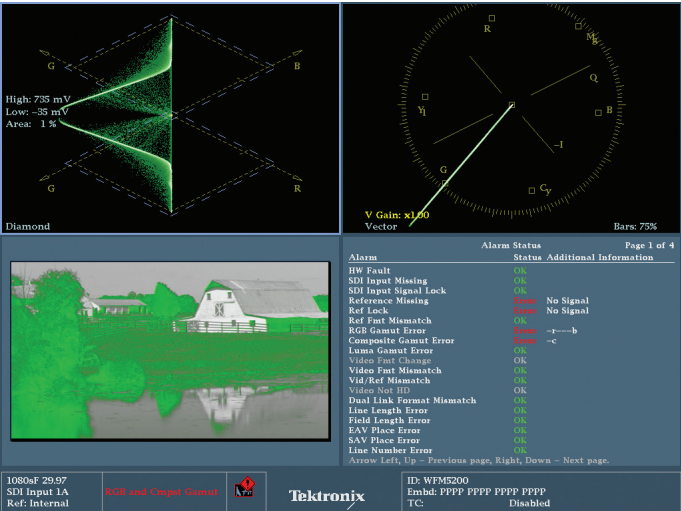


Figure 2-33. Diamond display with saturated green shadows.

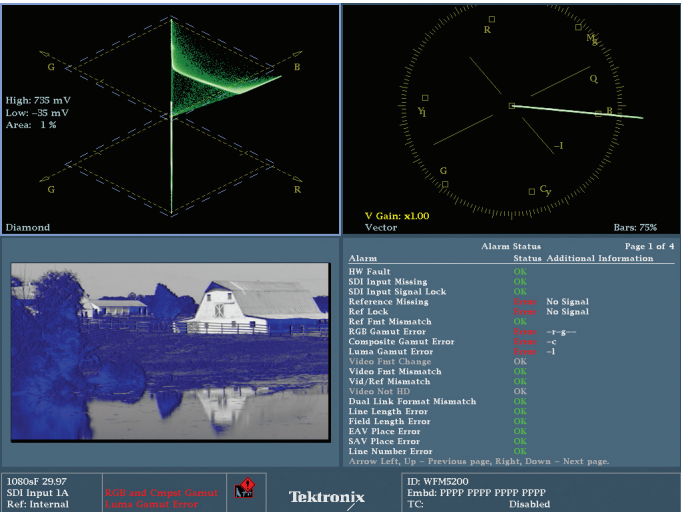


Figure 2-34. Diamond display with saturated blue shadows.

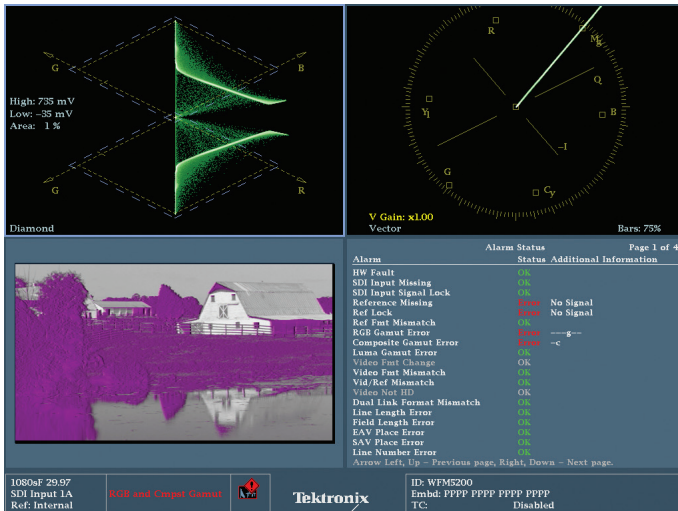


Figure 2-35. Diamond display with saturated magenta shadows.

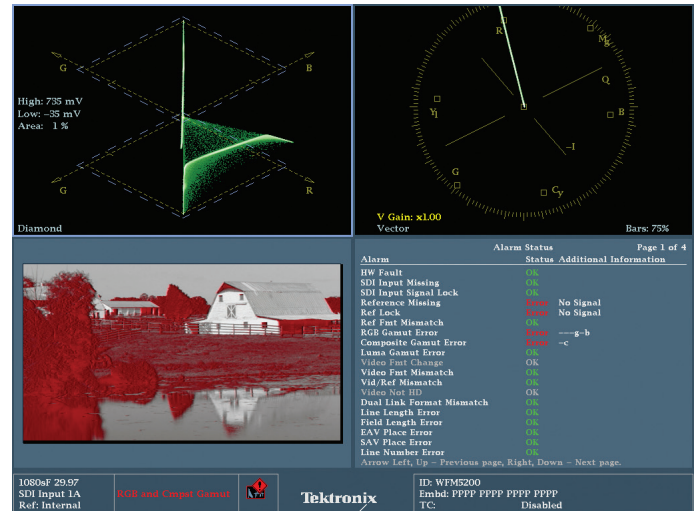


Figure 2-36. Diamond display with saturated red shadows.

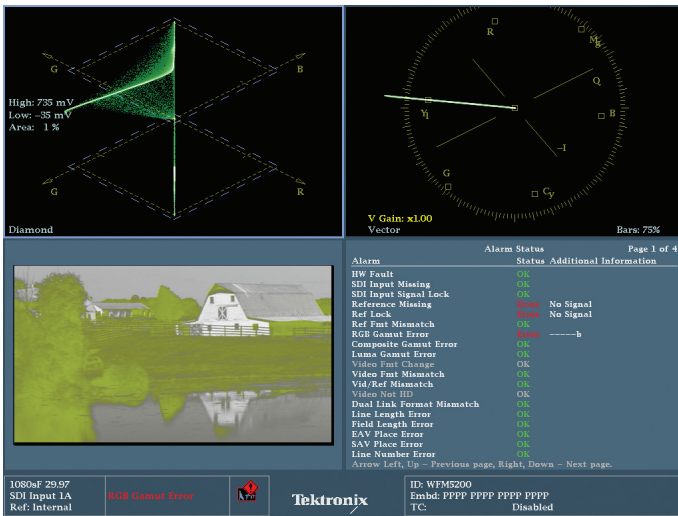


Figure 2-37. Diamond display with saturated yellow shadows.

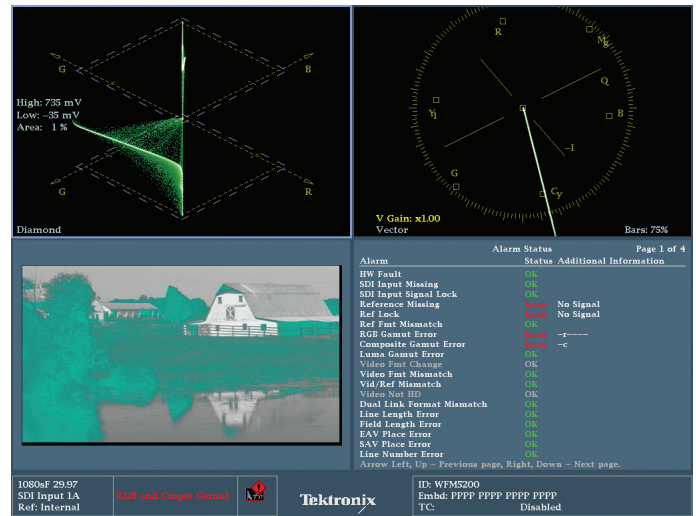


Figure 2-38. Diamond display with saturated cyan shadows.

Rolling the trackball to magenta, the trace extends to the right on both diamonds, which makes sense because magenta is made up of red and blue. The red and blue channels are represented to the right side of the diamonds (Figure 2-35).

Rolling to a perfect red, the trace in the top diamond is centered and the trace extends outside and to the right of the bottom diamond. This makes sense because the red channel is indicated by the bottom right half of the diamond (Figure 2-36).

Rolling to a perfect yellow, the trace goes to the left of the top diamond and the center of the bottom diamond (Figure 2-37). This connection is slightly harder to grasp, because yellow is made up of red and green. Red is indicated to the right

of the bottom diamond and green is indicated at the left of the diamonds. In the top diamond, there is no blue in yellow (yellow and blue are opposites) so the trace goes to the green side, but in the bottom diamond, since yellow is made up of equal parts of red (right) and green (left), yellow is indicated in the middle of the red/green diamond. The other color that works in this same way is Cyan.

Rolling to cyan, the trace in the top diamond centers because the top diamond is green/blue and cyan has equal amounts of cyan and blue (Figure 2-38). In the bottom diamond, the trace extends off to the left because cyan has no red in it (cyan and red are opposites), so the trace goes to the green side because cyan has green in it.

As an experiment, try this on your own system by lowering saturation on your color corrector so that there is no saturation, then use trackballs or color wheels in the shadows to push the color to some extreme, then, just using the trace on the Diamond display, try to guide the trace back into a perfect vertical alignment. With some practice, this will become second nature.

You can run through this same experimentation with the highlight trackball or color wheel. Without looking at the cursor on the color wheel, watch the Diamond display and try to “dial in” each of the primary and secondary colors perfectly. Then try to null out the colors, balancing the image in the center again. Then try the same experiment with the gamma or mid-tone trackball.

Another good experiment is to run this same process, but to use a preset where you can also see an RGB Parade monitor alongside the Diamond display or a vectorscope with the Diamond display. Seeing the Diamond alongside a display that you may be more used to will give you a good reference for what’s happening, almost like a side by side translation.

The advantage of using the Diamond display is that you can set your luma levels, saturation levels, and balance your colors all with a single display while intuitively monitoring gamut levels in every range.

COLOR GRADING WITH THE SPEARHEAD AND VECTORSCOPE

As explained in the section titled “Color Grading with the Spearhead Display“, if you imagine looking down at color space from above as being the vectorscope, then the

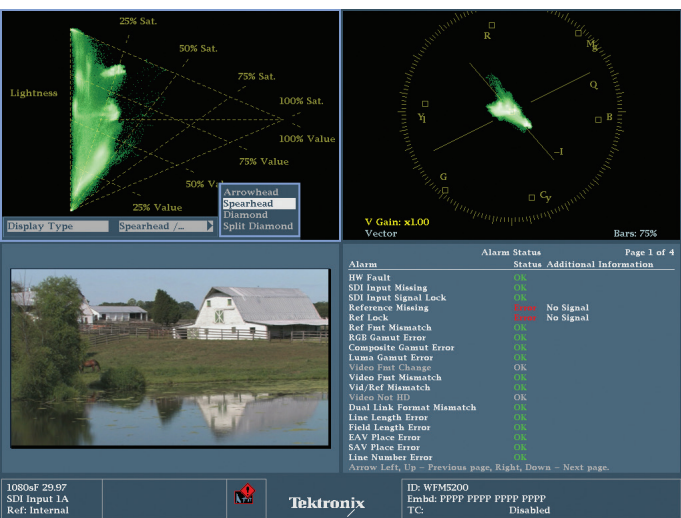


Figure 2-39. The Spearhead menu is accessed by holding down the GAMUT button for two seconds.

Spearhead is the same color space examined from the side (Figure 2-39).

The Spearhead shows black at the bottom left corner, white at the top left corner and saturation extends out from the left side to the right side. The value of the Spearhead is that in addition to showing luminance (up the left side vertically) and saturation, it also provides a quick method of checking for gamut issues and a good understanding of where those gamut issues are (in the blacks, whites or mid-tones). This makes level gradings easy to make with the Spearhead.

Balancing colors is not very intuitive with just the Spearhead, but combining it with the vectorscope really creates a very complementary view of color space.

Creating a Preset with the Spearhead Display

To run through a practical exercise in color grading with the Spearhead, create a preset using the Spearhead side by side with a vectorscope.

1. Use the thumbnail button to select one of the four quadrants on the Tektronix monitor (the selected quadrant is outlined in blue).
2. Press and hold the Gamut button. This brings up a menu with selections for Tektronix full range of Gamut displays: Arrowhead, Spearhead, Diamond and Split Diamond.
3. Use the right arrow to move to the list of gamut displays.
4. Use the up and down arrows to select the Spearhead display.
5. Press the Gamut button again to set your selection.
6. Use the thumbnail button to move to the next quadrant.
7. Press the Vector button to display a vectorscope in that quadrant.

If you want to, put other displays, like the Picture monitor and Status display in the other two quadrants, then use the directions in SAVING A PRESET to save this preset for recall and later use.

One way to check balance with the Spearhead is to see that a lot of the “weight” of the trace lines up along neatly along the left side of the triangle. Unbalanced images pull away from that line. If shadows are unbalanced, the trace pulls away at the bottom. If it pulls away in the middle, the gammas or mid-tones are unbalanced, and if it pulls away at the top, that indicates unbalanced highlights.

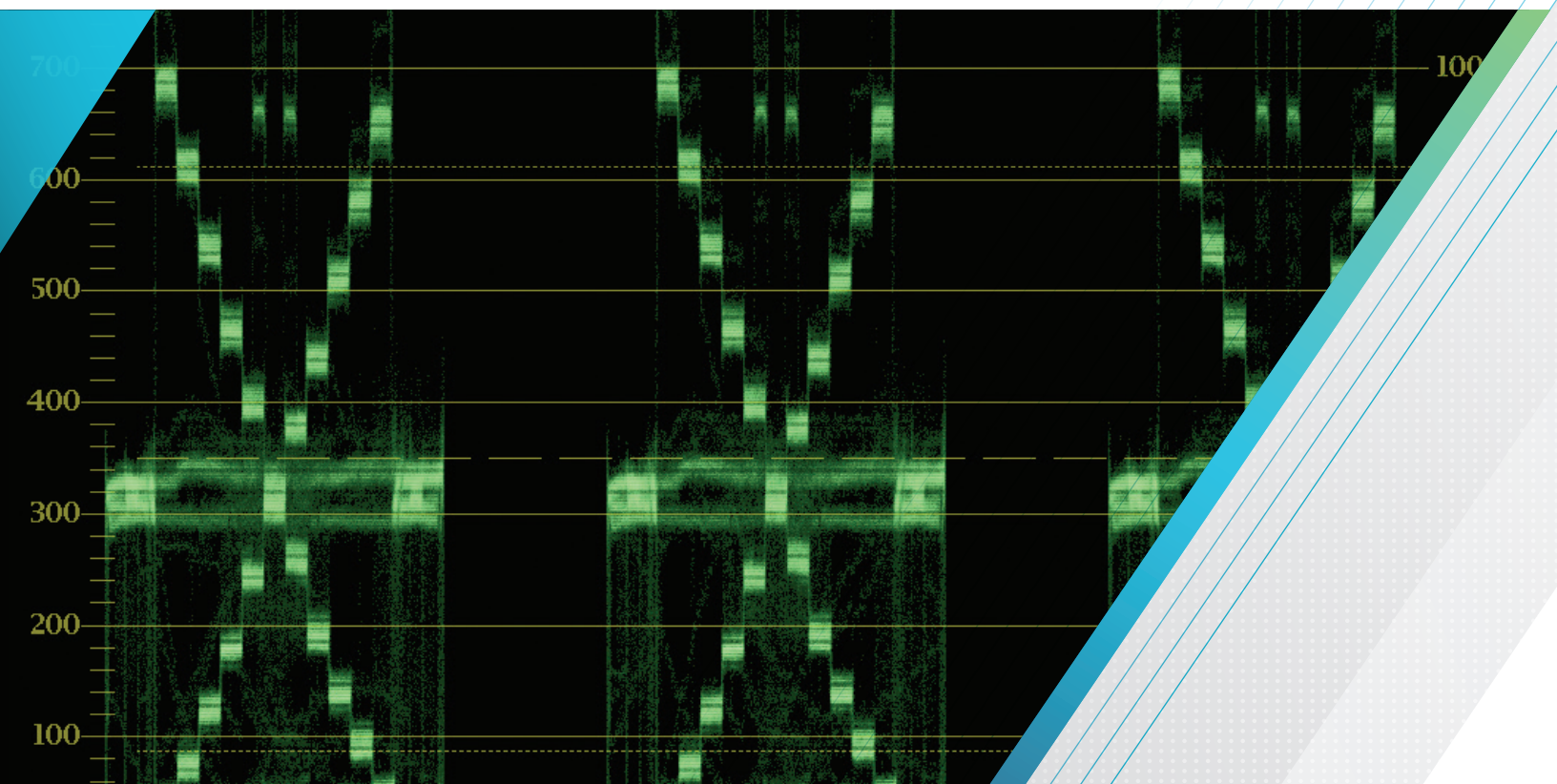


Figure 2-40. This image is well balanced. While saturated colors extend out to the right, the majority of the trace lines up along the left side from top to bottom.

Because of the way color space is folded in on itself in the Spearhead, figuring out how to correct these balance issues are not easy with the Spearhead by itself, but in conjunction with the vectorscope, it's quite easy to determine levels, fix gamut problems and color balance (Figure 2-40).

Section 3:

Chip Charts and Proper Levels for Each Tonal Range



Section 3 Chip Charts and Proper Levels for Each Tonal Range

To be proficient in doing color grading, it is necessary to understand the correlation between the video image and the waveform monitor. In particular, a colorist must be able to distinguish specific portions of the trace and relate them to specific elements in the video image.

To develop this skill, it's easiest to start with a very simple image. We'll use a CamAlign GrayScale Test Pattern from DSC Laboratories.

OVERVIEW OF USING CHIP CHARTS

These charts are used on multi-camera programs, like sports, news, talk shows, concerts and other live events to help align the colors and luminance levels of all of the cameras. Without this step, every time a different camera was selected on the switcher in a live event or each time a new ISO was chosen in a multi-camera edit, the colors would shift between cameras.

Notice the unique pattern that the chip chart forms on the waveform monitor (Figure 3-1). When properly adjusted, the pattern created in the waveform trace is uniform and identical in shape on each camera.

Let's correlate the specific "chips" (black, white and gray rectangles on the chart) with specific portions of the trace on the waveform monitor. The trace creates the shape of an "X" with a thick band running horizontally through the center and a small straight line on the bottom of the waveform monitor, centered horizontally.

The X is created by the two strips of stepped gray chips. The top strip of chips, which starts with bright chips to the left, creates the diagonal steps of the X that start in the upper left corner, descending diagonally to the lower right. The bottom strip of chips displays as the diagonal series of steps that starts in the bottom left continuing to the upper right. The gray background that makes up the majority of the chart is represented on the waveform by the thick horizontal line that runs between the 300 and 400mv level in the center of the waveform. The small horizontal line in the middle of the waveform at the bottom represents the small black patch in the middle of the chip chart.

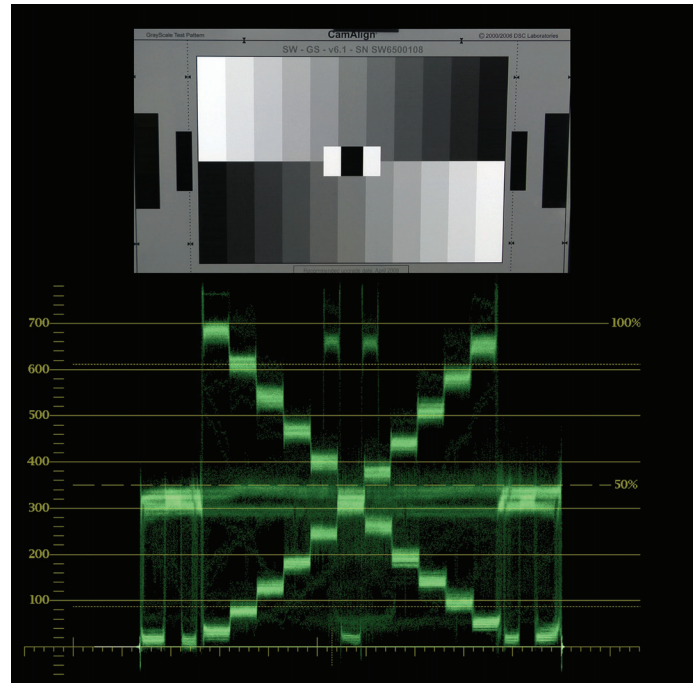


Figure 3-1. DSC Labs Grayscale test pattern aligned above the matching waveform monitor. All elements align vertically between the test pattern image and the trace of the waveform below it.

The important thing to remember when trying to correlate positions on the video monitor with positions on the waveform trace is that the horizontal positions of items in the image will correspond to the horizontal position on the trace. However, vertical positioning in the image is inconsequential to the waveform display. In the trace of the waveform monitor, the vertical position of anything in the trace is based on the brightness or power of the signal, the brighter it is, the higher it is. So dark things are at the bottom of the trace, mid-tones are in the middle of the trace and bright things are near the top of the trace. With certain settings on the waveform monitor, vertical position can also be affected by chroma levels as well.

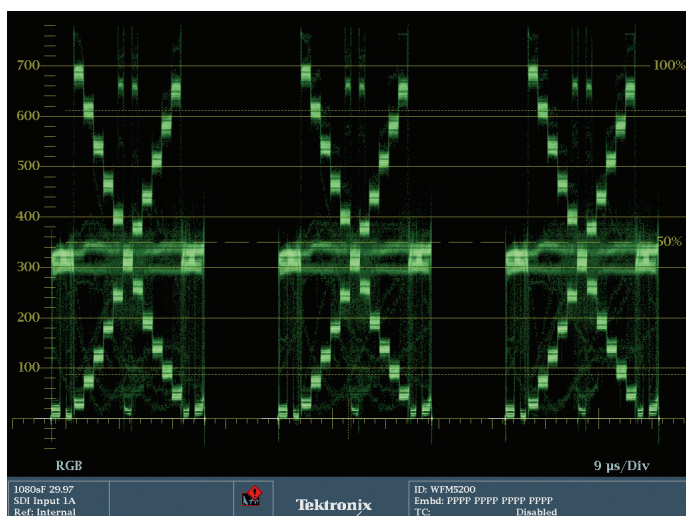


Figure 3-2. This trace represents a perfectly balanced grayscale test pattern. Each color channel is exactly equal across all three color channels. If the levels of the three color channels RGB are not matched in this grayscale chart they will cause color tints to the chart. The following images are several examples of different color casts.

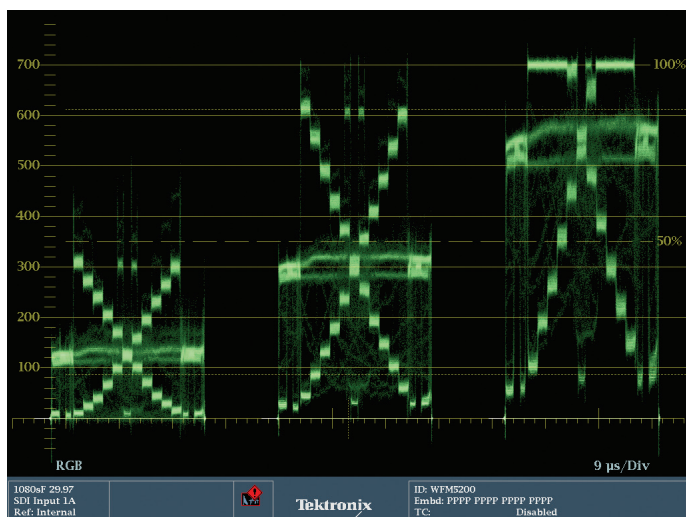


Figure 3-4. This trace represents a very cool, bluish, grayscale chart. The camera was set to tungsten balance, and then the chart was shot that was lit with daylight. Note the elevated blue channel and lowered red channel.

With a clear understanding of what the grayscale chart should look like on a standard “overlay” waveform monitor, look at the same chart on an RGB Parade waveform monitor. This will show you differences in the strengths of the levels in each color channel. If the grayscale chart is perfectly balanced, the red green and blue channels will be identical (Figure 3-2). To see this, use your color grading software to pull all of the saturation from a grayscale chart. However, we can’t balance most video footage by simply removing the saturation because then all of the images would simply be black and white. That’s fine for a grayscale chart, but not for the majority of video footage.

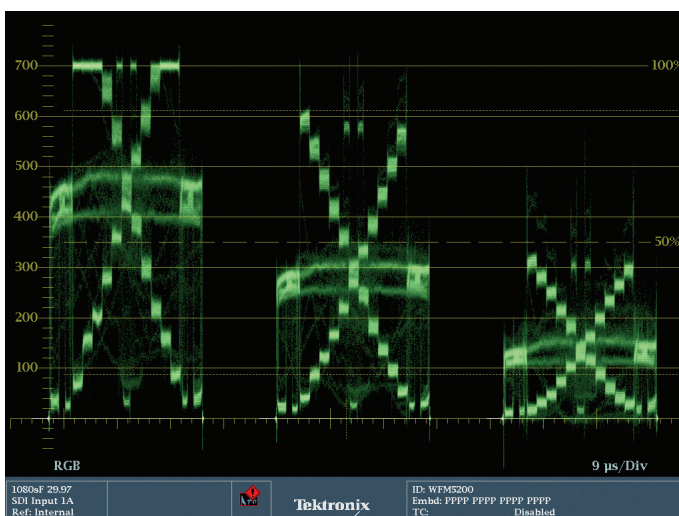


Figure 3-3. This trace represents a very warm, reddish yellow grayscale chart. The camera was set to daylight balance, and then a chart was shot that was lit by tungsten. Note the elevated red channel and lowered blue channel.

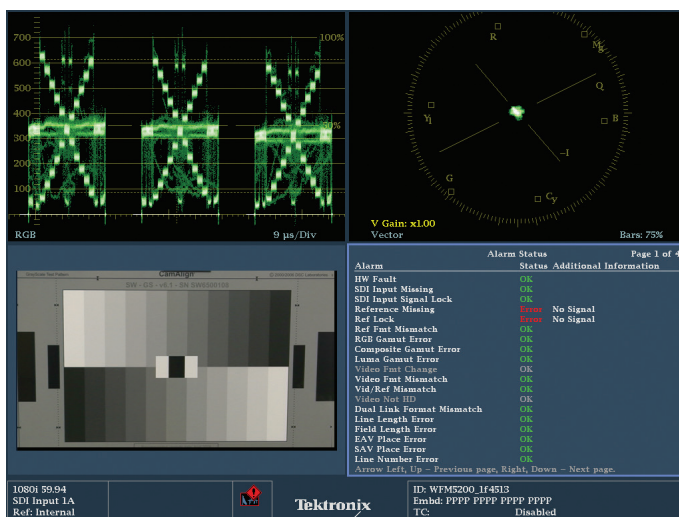


Figure 3-5. The picture monitor shows a grayscale chart that seems neutral, but the RGB Parade shows that the red level is slightly higher than the green level which is slightly higher than the blue level.

In order to properly balance a grayscale chart, each of the “chips” in the video image must generate a section of trace that is the identical height across all three channels (red, green and blue). This is because a properly balanced white chip has the same amount of red, green and blue. So does a properly balanced black chip.

Sometimes, using your eye, color grading may not even seem necessary for some images. However, upon closer examination using the RGB Parade waveform monitor, discrepancies between the levels can reveal a misbalance in the image. This is one of the reasons that it is so critical to use a waveform monitor as a reference instead of simply looking at the image on a video monitor.

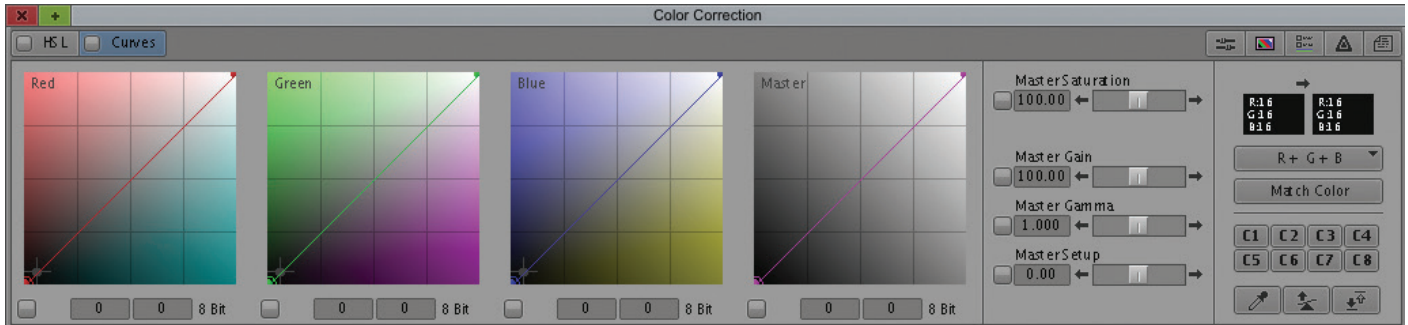


Figure 3-6. This is the Avid Curves control UI. Numerous color grading systems have a similar control. By adjusting the lower left corner of the Curve in each channel, you control the shadows. Adjusting the upper right corner controls highlights. Placing a control point in the middle of the “curve” and moving it up, down, forward or backwards allows you to control mid-tones in each channel.

Each color grading application uses a different set of tools. The most intuitive way to color balance when viewing an RGB Parade is to have direct control of the red, green and blue channels. Many color grading systems have a set of slider or “pot” controls that allow the shadows, mid-tones and highlights to be controlled for each of the three color channels. Another way to control the red, green and blue channels is to use Curves controls (Figure 3-6).

Black levels are the first thing to adjust (Figure 3-7). The goal is to bring the bottom of each color channel down to the 0mv level (Figure 3-1). The shapes at the bottom of the trace for each channel should be even. On this particular chart, there are black chips in the middle and two off to the sides. The goal is to bring the part of the trace associated with these five black chips down to 0mv. Also, as levels are lowered, the shapes of the trace should not flatten out at the bottom. When the trace shapes flatten out it indicates that detail in the shadows is being lost. This is called “crushing the blacks”.

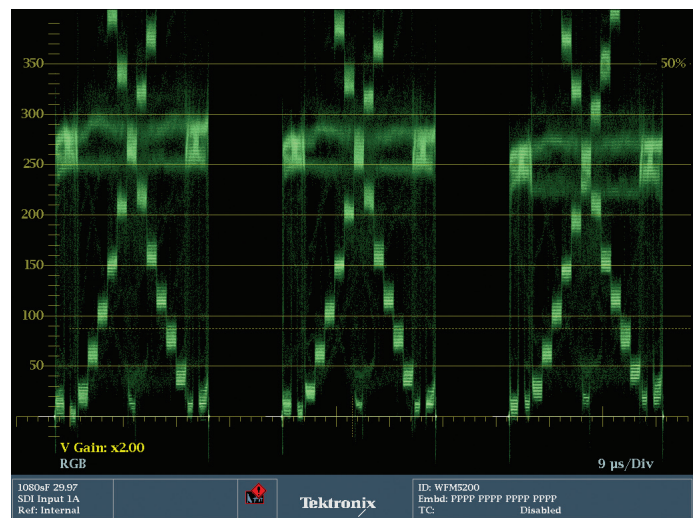


Figure 3-7. With an RGB Parade set to 2x gain and focused on the shadows, it's easier to see the exact levels for the blacks or shadows in each color channel. Between 200 and 300 mv, it's plain that the balance is still off in the higher tonal ranges, but the levels are even in the blacks. Each color channel just touches the 0 mv line.

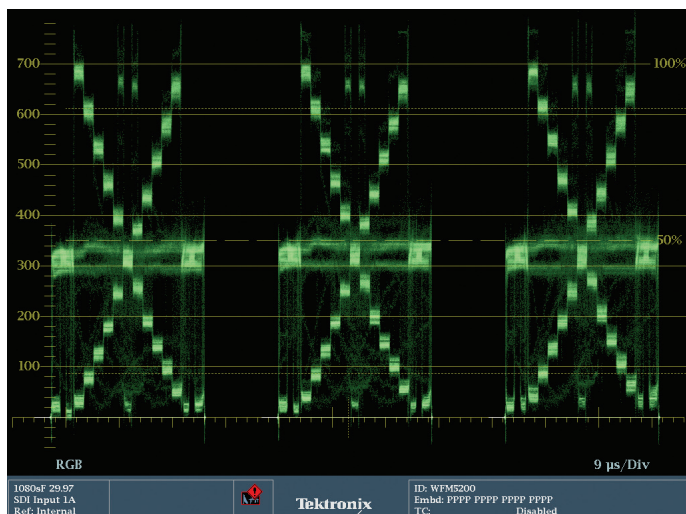


Figure 3-8. Note that the highlights and mid-tones are balanced across all three color channels. Compare this to Figure 3-5.

With the levels even across all three channels in the blacks, use the controls to alter the highlights of the red, green and blue channels to balance the height of the trace in each of the channels (Figure 3-8). The brightest white on this particular chart is in the chips at the top of the “X” in the trace. The level for these chips - and anything else that’s bright in the shot - should not exceed 700 mv or 100%. As with the black levels, the shapes of the trace for each channel should not flatten out at the top. When the trace shapes flatten out, it indicates that detail in the highlights is being lost. This is called “clipping the highlights”.

Often, when the shadows and highlights are balanced, the mid-tones are corrected as well. If the mid-tones are not balanced across all three color channels, use the mid-tone or gamma sliders to bring them to the same level.

Another critical and useful Tektronix display for setting up grayscale charts is the Diamond Display. To recap the Diamond Display, black is at the center of the two diamonds, white is at the top of the top diamond and the bottom of the bottom diamond. All levels of pure gray extend from the center point out to the two tips of the diamond, in a perfect vertical line through the middle of the display.

To get a sense of how the Diamond can help in color balancing, we’ll use the same corrected grayscale chart, viewed in the Diamond display. When the Diamond is reading the corrected

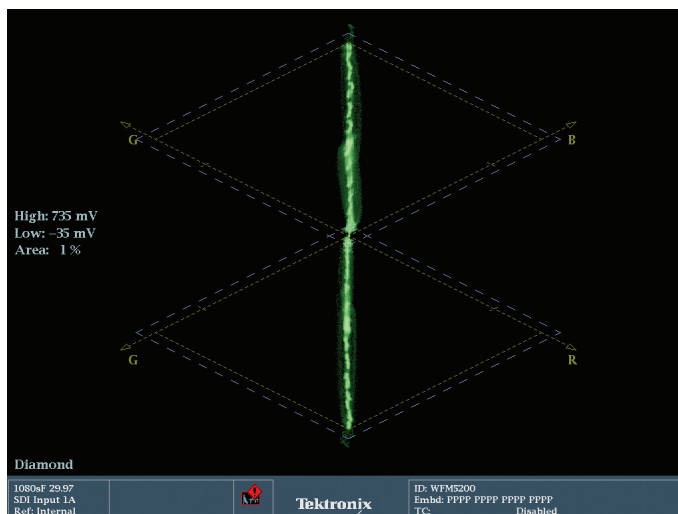


Figure 3-9. The Diamond display showing a well-balanced grayscale chart. The trace is a perfect vertical line.

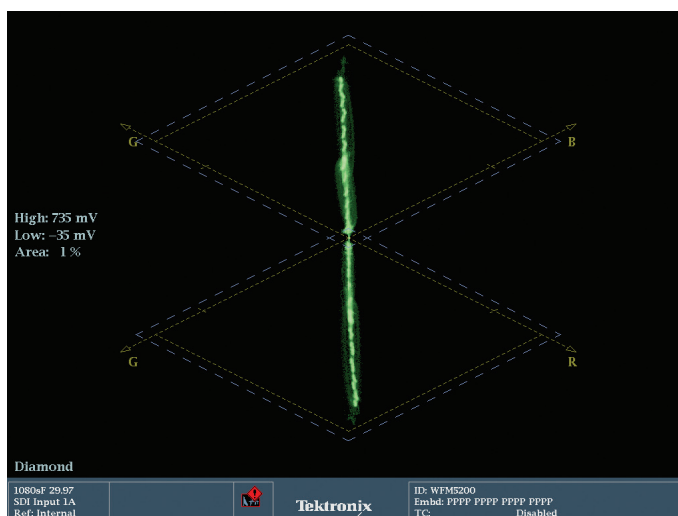


Figure 3-10. The Diamond display is showing the unbalanced grayscale chart. Note that the highlights at the top and bottom of the display skew off towards the green vector at the top and the red vector at the bottom.

grayscale chart, the trace lines up perfectly in a vertical axis (Figure 3-9). But when we return to the uncorrected version of the chart, you can see that the highlights veer away from the perfect vertical line towards red and somewhat towards green (Figure 3-10). Remember that the uncorrected grayscale needed very little balancing in the blacks. This is also evident in the Diamond display because the blacks, which are visible where the two diamonds meet, are centered nicely.

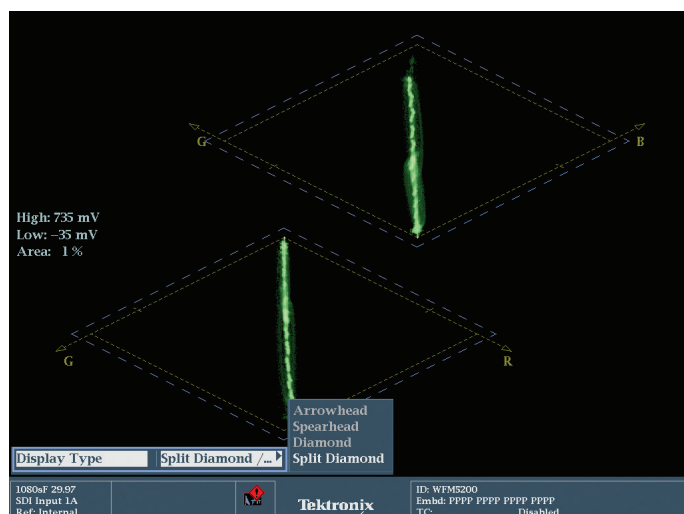


Figure 3-11. The Split Diamond display makes it easier to see the levels and balance of blacks. The display is identical to the regular Diamond display except that the top and bottom diamonds are off-set from each other.

Black needs to be as close to the center of the two diamonds as possible (Figure 3-11). The top diamond shows the interplay between blue and green. The bottom diamond shows the interplay between red and green. Whites need to be centered and as far to the top of the top diamond as possible and as far to the bottom of the bottom diamond as possible. The balance of both diamonds relies on green. The goal is to get the blacks centered in the nexus of the two diamonds. The bottom diamond describes the red/green ratio and the blacks or shadows of the bottom diamond are at the top of it. At the center of the two diamonds it may be hard to see where exactly the black level is hitting. One way to set the black level is to look for the Gamut Warning, then back off a bit until that goes away. The other possibility to better monitor black level is to hold down the Gamut button to go into the Gamut menu and switch from Diamond Display to Split Diamond Display. The Split Diamond display offsets the two diamonds in the standard Diamond Display for the express purpose of allowing a clearer view of the black levels at the juncture of the two diamonds.

Another tip to dialing in black levels and black balance is to switch displays from the Diamond to the Lightning display (Figure 3-12), which is one of the vectorscope options. With the Diamond, you can't zoom in to a region of interest like you can with a waveform monitor or vectorscope, but with the Lightning display, the GAIN controls do work and the overall image on a Lightning display that is zoomed in is similar to what you would get if you could zoom in on a Diamond display.

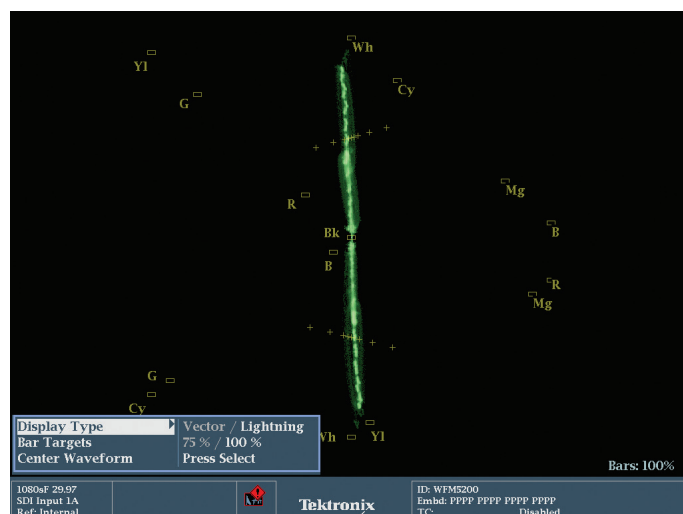


Figure 3-12. Tektronix Lightning Display. Though the graticule is laid out differently than the Diamond, the trace display is similar, with black in the middle and a balanced, neutral trace extending up and down vertically from that.

To set up and complete the black balance with the Lightning Display:

1. Press the **VECTOR** button to call the vectorscope up full screen.
2. Press and hold the **VECTOR** button for two seconds to see the VECTOR menu options.
3. In the Display Type Option, use the right arrow to select Lightning.
4. Press the **VECTOR** button again to save that choice and get out of the VECTOR menu options.
5. Press and hold the **GAIN** button for two seconds to see the GAIN menu options.
6. Use the down arrow key to choose the Gain Settings option.
7. Use the right arrow to move to the 1x gain option.
8. Use the up and down arrows or General dial to choose the 10x option.
9. Press the **GAIN** button again to save that choice and get out of the GAIN menu options.

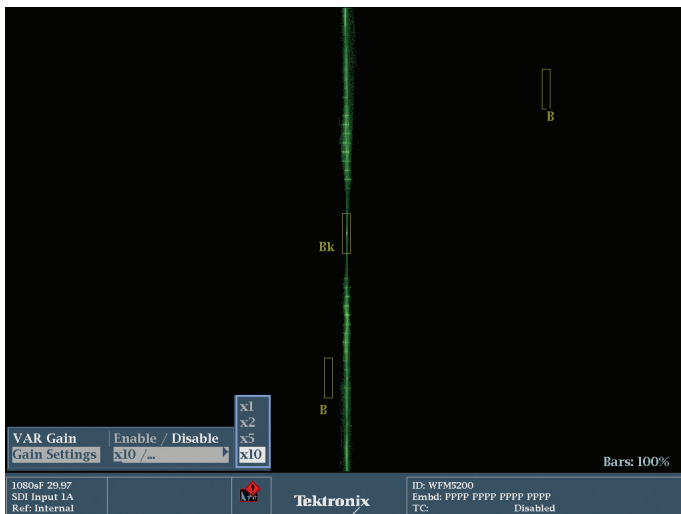


Figure 3-13. The Lightning display with 10x gain. The Gain menu is on screen and the option for 10x is chosen.

With the Lightning display properly set up, the black level and balance is in the center of the display. There is a sharp, clean part of the trace that goes through the middle of the target marked Bk (black), see Figure 3-13. The goal is to use the master black control to adjust the fuzzy part of the trace to meet in the middle without overlapping too much. As it overlaps, you'll see that the Gamut or Luma error will appear on screen.

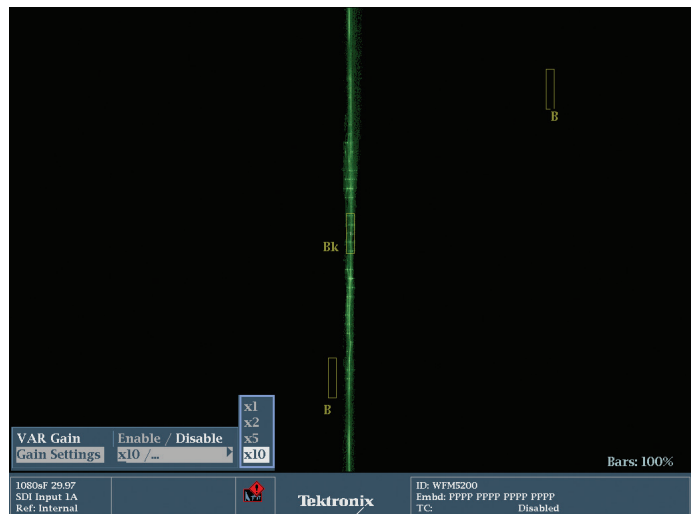


Figure 3-14. Note the difference in the trace between this Figure and the previous one. The blacks are lowered - getting the thicker part of the trace closer together in the center and are centered better horizontally, the top part of the trace directly above the bottom part of the trace.

By manipulating the shadows in the red, green and blue channel, you will see that the trace becomes off-centered. The goal is to center the trace on the Bk target. This is basically what you were doing with the Diamond display, but the Lightning display gives you a much more detailed view.

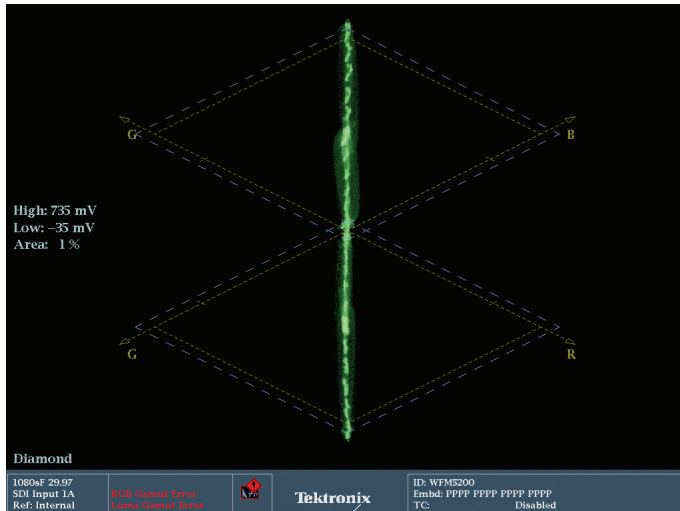


Figure 3-15. Note that the RGB Gamut Error and Luma Gamut Error warning is on at the bottom left side of the Tektronix display and that the trace of the Diamond extends beyond the yellow dotted line. Reducing the Gain control in the color grading application will solve this error.

After setting shadows using the Lightning display, we'll switch back to the Diamond display to balance the highlights. Starting with green again, it will not be possible to get the green highlights (top of the top diamond and bottom of the bottom diamond) both to line up properly using only the green controls. When one diamond starts to line up properly, but the grading takes the other diamond further out of balance, the green highlight control must be manipulated so that the best compromise between the two diamonds is made. In other words, it is set so that both diamonds are equally out of balance in different directions. Then, to finish the highlight balance, the red highlight control is used to center the trace at the bottom of the lower diamond, and the blue highlight control is used to center the trace at the top of the upper diamond (Figure 3-15).

To determine the gain level, the overall master gain is adjusted until the trace reaches the internal dotted yellow line of the Diamond display, or until the gamut or luma warning on the Tektronix display appears.

If the mid-tones were unbalanced across the width of either diamond, you could use the gamma or mid-tone controls of the three color channels to manipulate the mid-tones into balance.

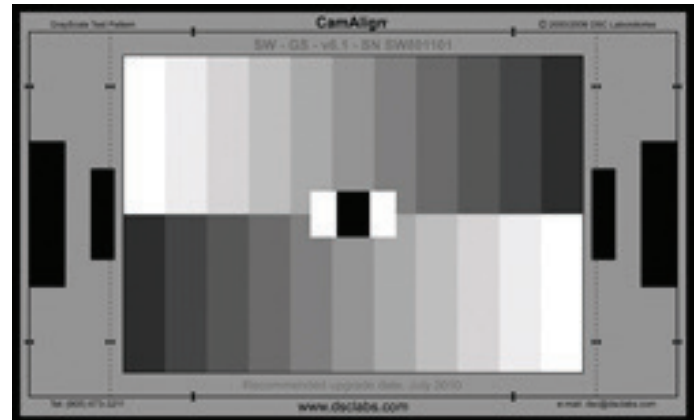


Figure 3-16. This is a DSC Labs Grayscale chart. This chart helps in setting up multiple cameras.

PROPER LEVELS FOR EACH TONAL RANGE

One of the benefits of having a waveform monitor is that it gives you a visual reference to what is happening on your picture monitor that provides specific, quantifiable cues as to what needs to be done and what is happening as you make gradings. Just looking at the picture monitor can help to define a look, but the waveform monitor gives a reference that shows whether you need more or less of a specific color channel and whether you need to adjust controls in a specific direction or by a specific amount like a compass or a GPS. A waveform monitor can help develop an understanding of how the image is being manipulated.

With color grading, one of the desires and needs of the colorist is to have as much specific control as possible. Certain controls in certain NLEs and color grading systems give you great control and others rob you of control.

Using these tools with an easily understandable video image, like a grayscale chart (Figure 3-16) shows what's happening as these controls are used and can help in your understanding of how to achieve a specific look later on when you are grading "real world" images.

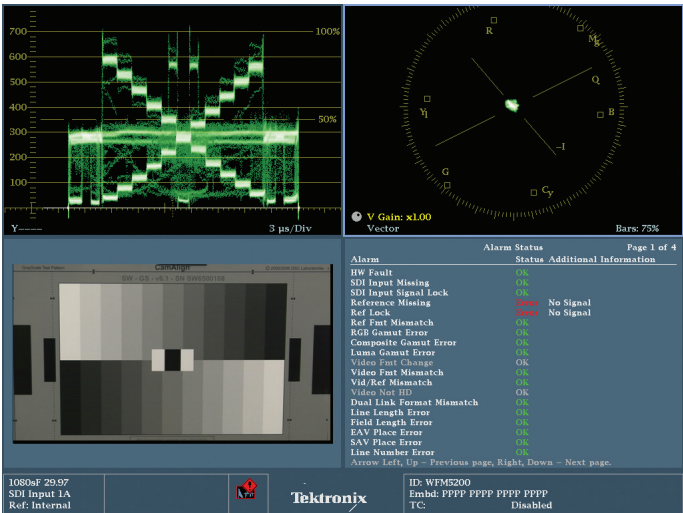


Figure 3-17. A starting point for color grading. Note that the levels are not at 100%.

A commonly misunderstood and misused tool in color grading - especially on NLEs - is the brightness control. While it would seem that the brightness control is the same as a gain control, they both do things quite differently. Seeing the difference on a video monitor might be difficult, but with a waveform monitor, the difference is quite apparent.

A grayscale image was loaded into a color grading system that has a brightness control and a gain control. Notice the current level of both the blacks and the whites (Figure 3-17).

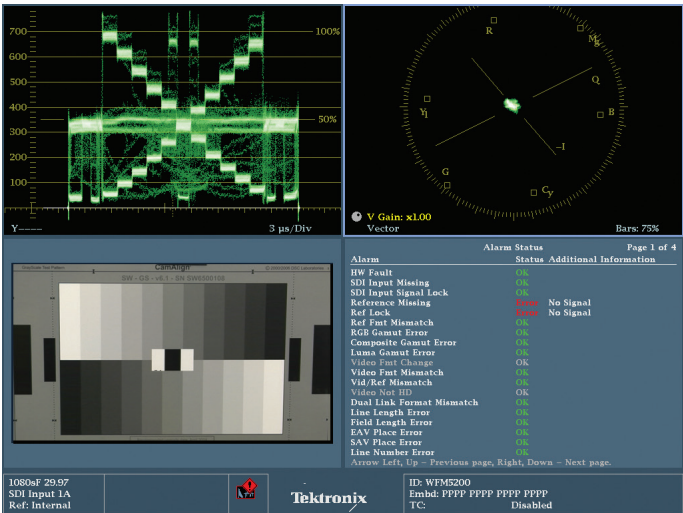


Figure 3-18. After using the Gain control, the highlight levels reach 100% and the blacks don't move much.

Using the gain control, the levels were increased so that the whites reached 100. With gain controls, only the highlights really changed. Some of the mid-tones rose a little and the blacks may have come up a few percentage points, but will mostly stay where they started (Figure 3-18).

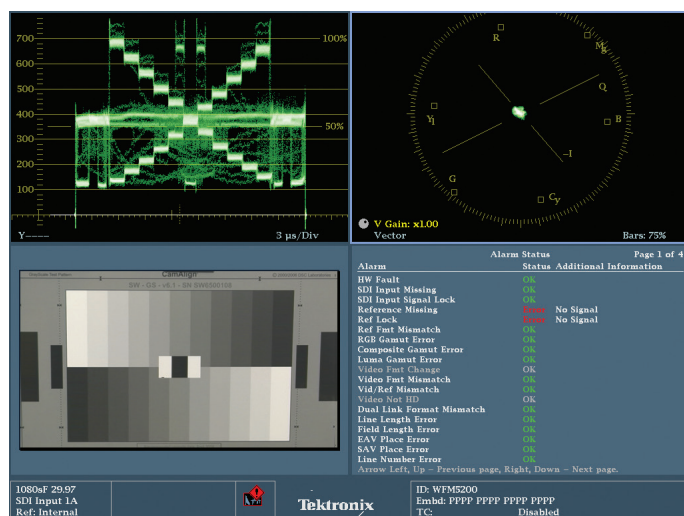


Figure 3-19. After using the Brightness control to achieve proper 100% highlight levels, note the very high level of blacks compared with the same grading using Gain.

However, when the brightness controls were used to brighten the image, it's obvious that the highlights are not the only things that change (Figure 3-19). The entire signal was raised by equal amounts. It's possible that this is the desired effect, but it is more common that the colorist wants to adjust black levels and highlights by different amounts, even in opposite directions in most cases.

The other control that is similar to this is the contrast control. Adjusting the contrast control alters the entire signal by either expanding or compressing it by the same amount from both extremes of the signal. Increasing contrast pushes the shadows lower by the same amount that it pushes the highlights higher (Figure 3-20). Decreasing contrast lifts the shadows by the same amount that it lowers the highlights (Figure 3-21). This control is not generally helpful to the colorist, because the colorist wants to adjust the top and bottom of the image - the highlights and shadows - by different amounts.

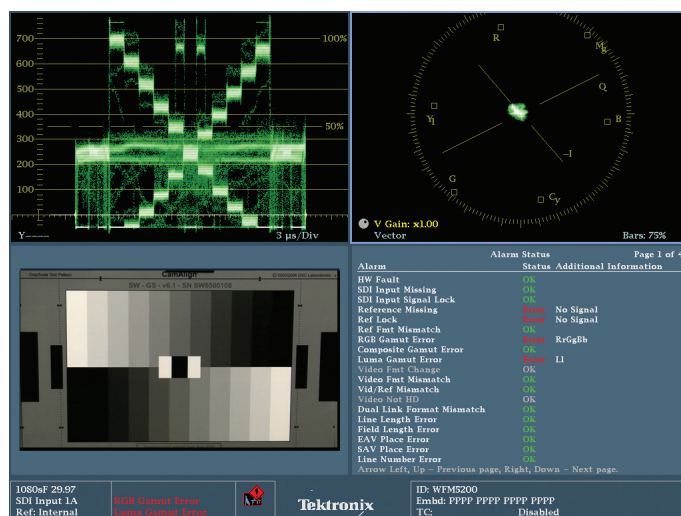


Figure 3-20. The contrast has been increased here. Note that in addition to increased contrast, the blacks are much more crushed than the highlights. This uneven increase in contrast in one tonal range over another is indicative of using contrast controls instead of individual black, gamma and gain controls to control contrast.

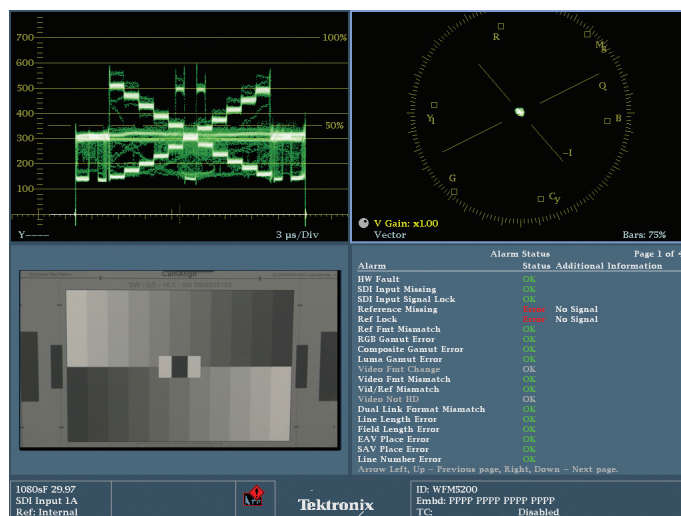


Figure 3-21. The contrast has been decreased in this example. Note that the blacks are raised less from true black compared to the amount that the highlights have been decreased from 100% of signal. Using the contrast controls robs the colorist of important control.

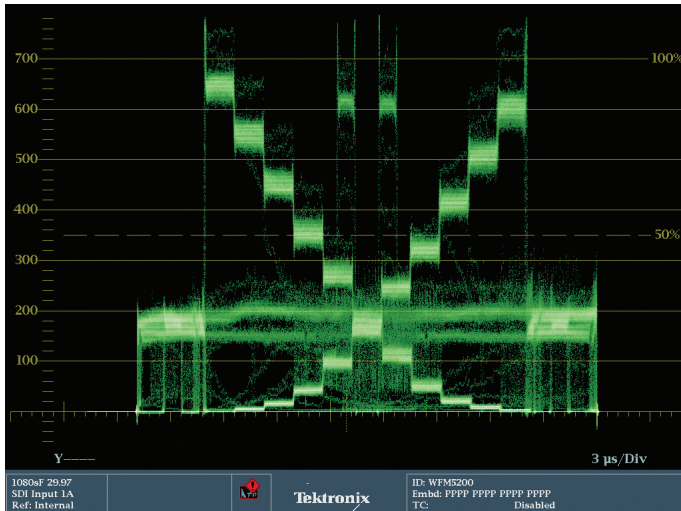


Figure 3-22. A waveform monitor showing crushed grayscale. Note that the difference between the “steps” in the shadow chips is virtually indistinguishable. Compare that to the image of the “crushed” chart.

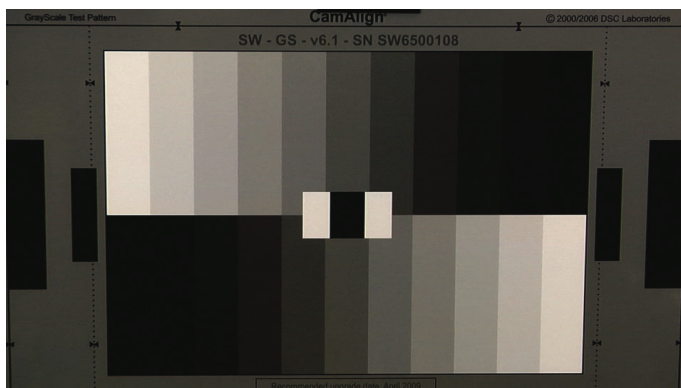


Figure 3-23. This image represents the “crushed” grayscale chart. Note that the “steps” in the trace in Figure 3-22 that are indistinguishable on the waveform are also hard to distinguish as separate amounts of gray on the image.

Clipping and crushing has been discussed earlier in this Primer, but watching the blacks clip in a waveform monitor (Figure 3-22) while checking the black levels on a video monitor can clearly show how the flattening of the trace in the waveform relates to lost detail in the shadows (Figure 3-23). Use a Setup, Black Level, Shadows or Lift control to bring the blacks down on a grayscale chart. As the blacks start to crush, with the trace flattening out at the bottom, notice how the black chips become indistinguishable as each chip or “step” in the trace crushes to a similar level.

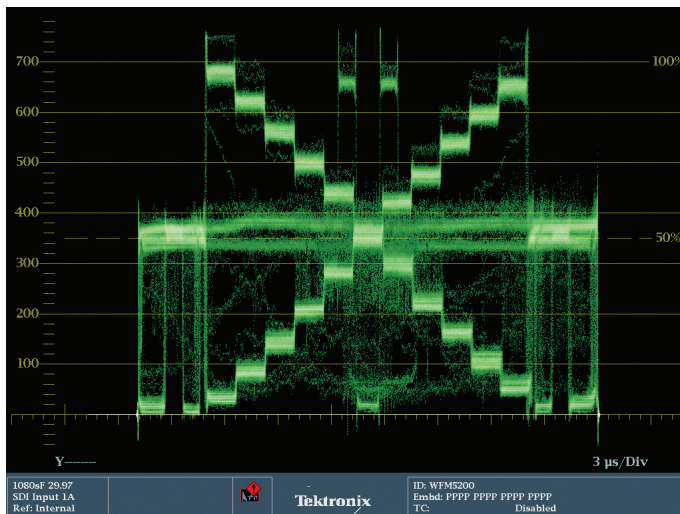


Figure 3-24. Note that with the shape of the highest “steps” in the trace, the edges at 100% have a soft shape to them. Compare this to the sharp, flat shape that the trace takes on as the chart becomes clipped in the highlights. Unless a “clipped” or “blownout” look is desired, the goal is to maintain this shape in the waveform without compressing the shape into a flatter, sharper, denser line in the trace. Compare to the next image.

Try this with whites as well (Figure 3-24), adjusting gain controls to raise whites up past the point where the trace starts to flatten out on top. As the trace flattens, notice the loss of detail in the highlights (Figure 3-25). Sometimes this clipping or crushing is a bad thing and sometimes it is desirable. The key is to see with your eyes the relationship between the video image, the trace on the waveform and the controls at your disposal.

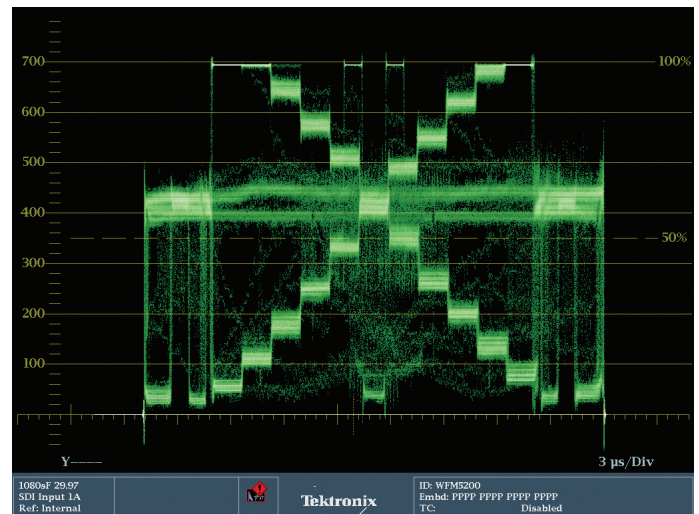


Figure 3-25. Note that the shape of the highest “steps” in the trace, right at 100%, has become a hard, sharp line. Each of the highest “steps” in the trace is indistinguishable from each other. Compare this to the shape of the “steps” in the trace in the previous image.

The concept of clipping and crushing is important when trying to increase or decrease detail. The shape of the trace in the waveform is flexible. Some gradings can be applied and they merely shift the trace up or down, but as the grading increases, the trace actually begins to distort. Shapes in the trace compress. As soon as these distortions become apparent, detail is being lost and also possibly causing misbalances in the relationships between color channels.

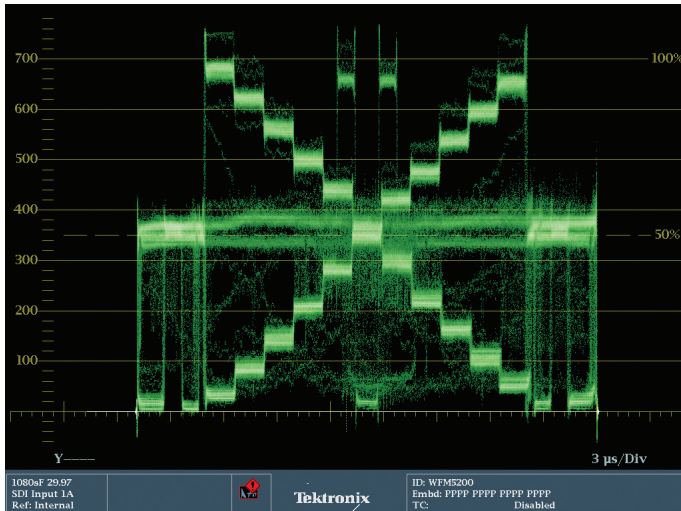


Figure 3-26. This trace shows the normal gamma for this grayscale chart. Note the even, uniform stair step pattern from the bright white chips down to the black chips. They form two crossing, diagonal lines.

A final tonal adjustment is the mid-tones or gammas. With the grayscale spread out with blacks at 0 and whites at 700 mv or 100%, adjust the gamma controls and notice the shape of the “X” in the waveform trace (Figure 3-26). As the gamma moves up and down, the straight lines of the “X” begin to curve (Figures 3-27, 3-28). Actually, the word “gamma” means “the characteristic of a curve.” By adjusting the gamma, you are altering the curve between your white point and your black point. As you lower your gamma, notice that the contrast between blacks and mid-tones is decreased while the contrast between your gammas and highlights is increased. This is an important thing to remember. Contrast doesn’t occur only in the full range of the image, but can be accentuated between specific tonal ranges. Raising the gamma will decrease the contrast between mid-tones and highlights and increase it between shadows and mid-tones.

Gamma or mid-tone gradings are more reliant on the video monitor and your eye than they are on the waveform monitor. This is a place where your sense of the overall brightness or richness of the image is the central factor in determining the proper level.

To learn more, watch these short “How-To” Guides on [Camera Shading](#), and [Tonal Range and Color Correction](#).

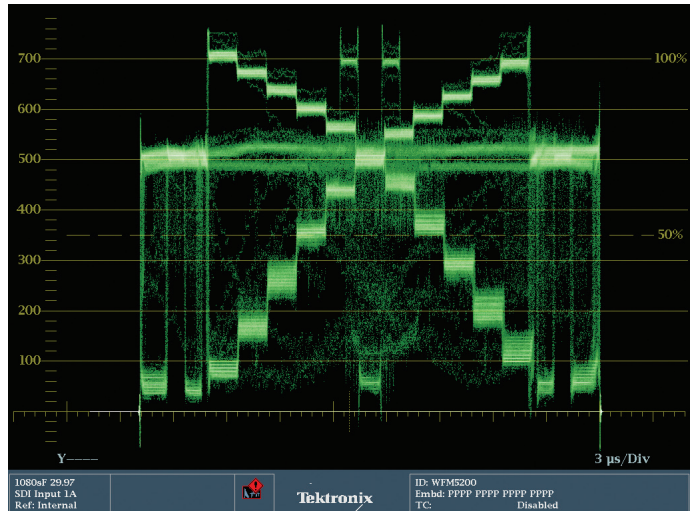


Figure 3-27. This trace shows the same chart with the gamma raised or lifted. Note that the lines that had been diagonal are now curved upwards from the “normal” chart. There is less contrast in the highlights and more contrast in the shadows.

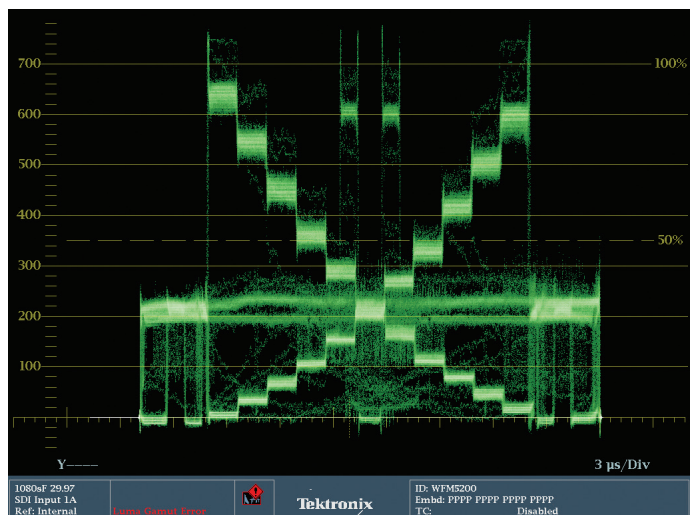


Figure 3-28. This trace shows the same chart with the gamma lowered. Note that the lines that had been diagonal are now curved downwards from the “normal” chart. There is more contrast in the highlights and less contrast in the shadows.

Section 4:

Using a Waveform Monitor as a Creative Tool

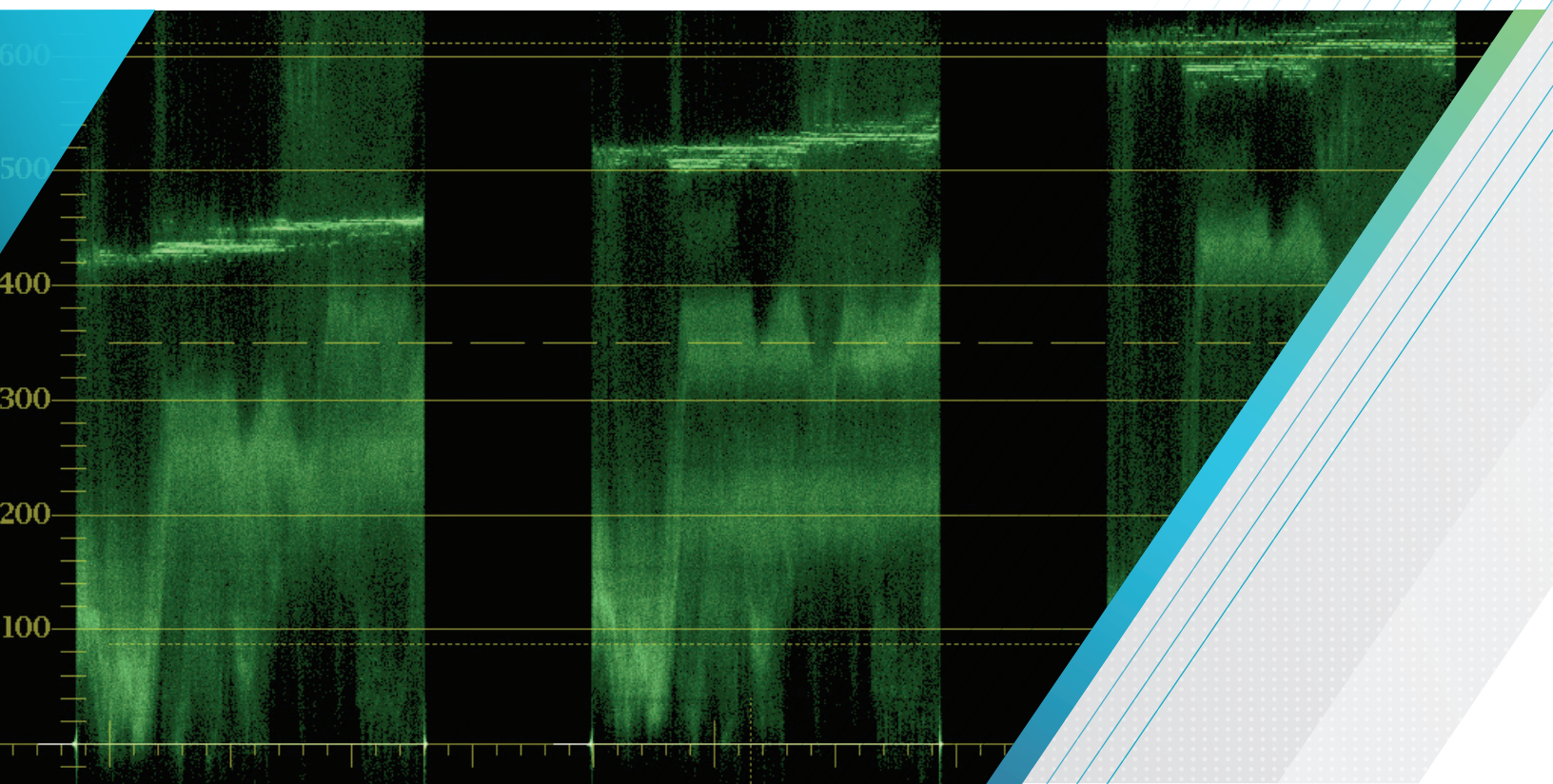




Figure 4-1. Coit Tower.

Section 4 Using a Waveform Monitor as a Creative Tool

In the previous section, the basics of using a standard RGB and Diamond display were explained. However, all of the examples were done with grayscale charts. With an understanding of how to balance a chart consisting of purely neutral tones, the next step is to transition those skills to work on images exhibiting a full range of color hues and tones.

Understanding the correlation between waveforms and video images is critical when colorists attempt to locate parts of the video image that they want to use to balance colors. Being able to identify a white shirt or the black tires of a car allow the colorist to balance the corresponding portions of the trace in an RGB waveform. The following exercises are designed to help you compare the video image with the waveform.

This is Coit Tower in San Francisco. The image is very simple and will be a good starting place (See Figure 4-1).

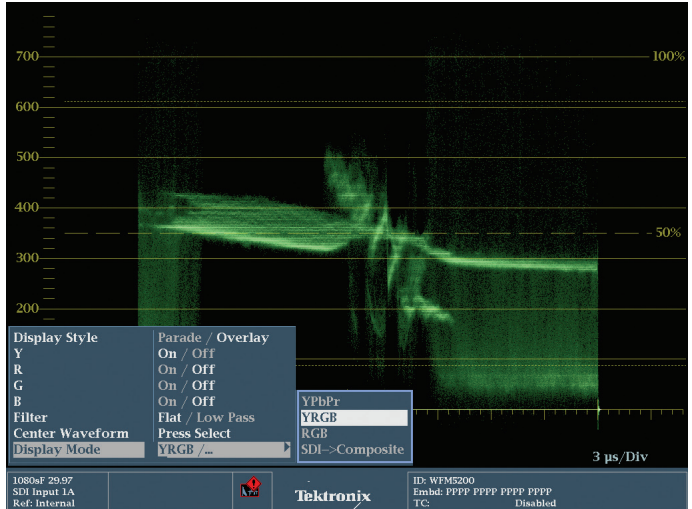


Figure 4-2. The waveform monitor menu set to display Y (luma) only.

Let's look at this image with a standard "overlay" waveform monitor (Figure 4-2). To see it at the greatest detail, we will call the waveform display up full frame on the WFM 5200. To call up an overlay waveform and display it full-frame:

1. Press the WFM button to call up your WFM menu choices.
2. Set your options to: Display Style> Overlay, Display Mode>YRGB, Y>On, R>Off, G>Off, B>Off.

This lets you see just luma.

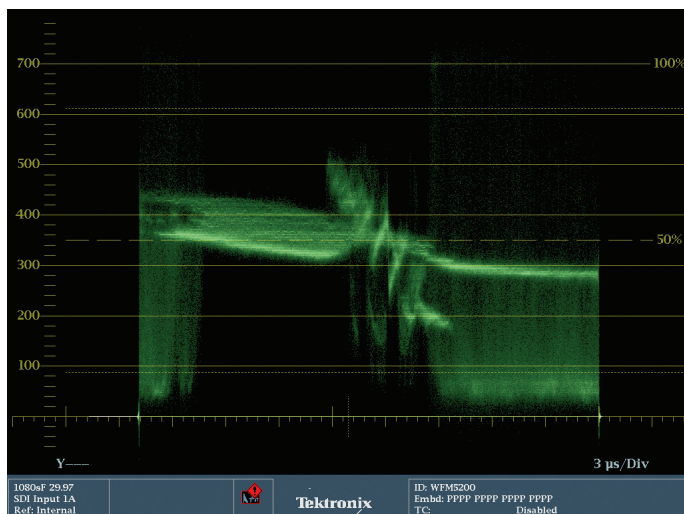


Figure 4-3. The luma only waveform display of the Coit Tower image.

On the left side of the screen, the trace goes from near black up to almost 700mv, though most of the signal is around 400mv (Figure 4-3). This area corresponds to the trees on the left side. They are mostly dark, but have highlights that are the brightest areas of the picture. Across the middle of the waveform, running from edge to edge is a rough angled area that represents the sky. It is darker (lower) on the right side than the left. In the middle of the waveform is the area corresponding to the tower itself. The brighter (higher) parts of the trace are on the left, where the tower is lit by the sun, and the shaded parts of the tower are on the right. There are two diagonal lines just to the left of center at about the 50% luma level. These diagonal lines are the central shaded concave curves of the tower that have a little more shade to them. The far right shaded side of the tower is represented by the thick bit of trace at about 200mv. The area on the right that goes from nearly black up to 700mv is the tree on the right, indicating the darker, shaded leaves and the bright highlights.

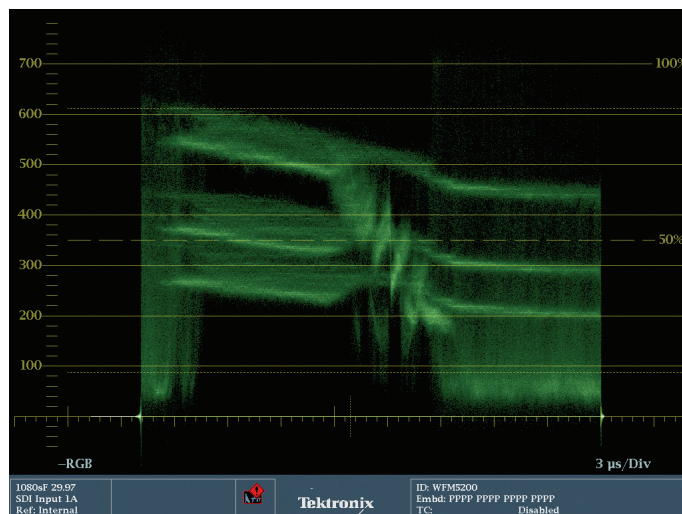


Figure 4-4. The RGB Overlay display of the Coit Tower image.

To see what this looks like in full RGB overlay mode (Figure 4-4):

1. Hold down the WFM button to recall the WFM menu options
2. Set your options to: Display Style> Overlay, Display Mode>YRGB, Y>Off, R>On, G>On, B>On.

This lets you see the red, green and blue channels laid on top of each other.

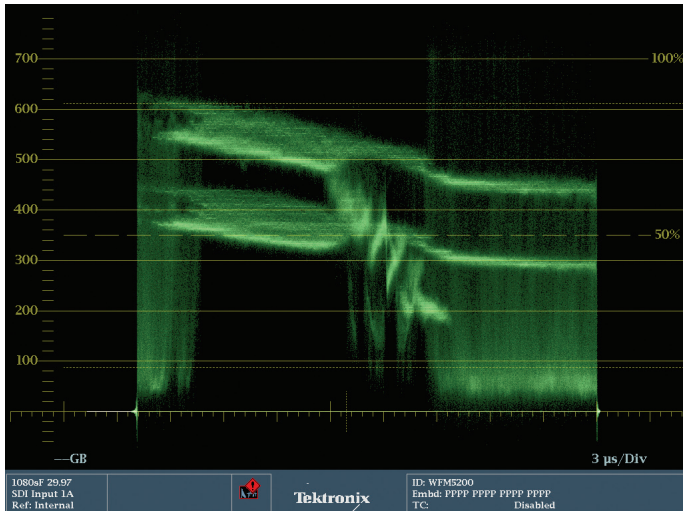


Figure 4-5. The RGB Overlay display of the Coit Tower image with the red channel turned off.

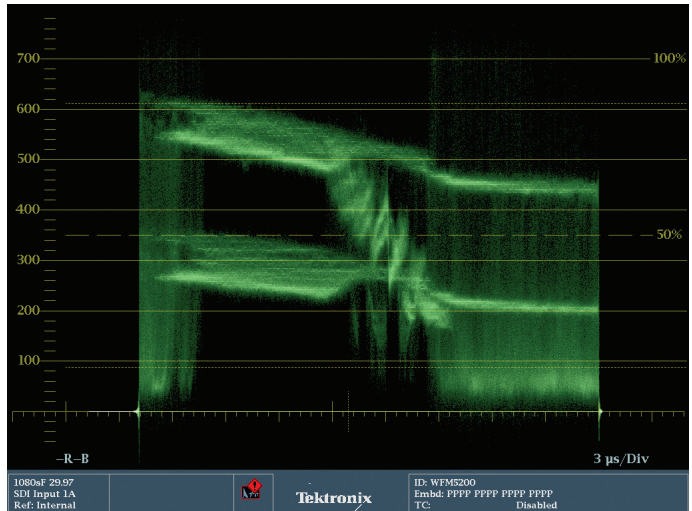


Figure 4-6. The RGB Overlay display of the Coit Tower image with the green channel turned off.

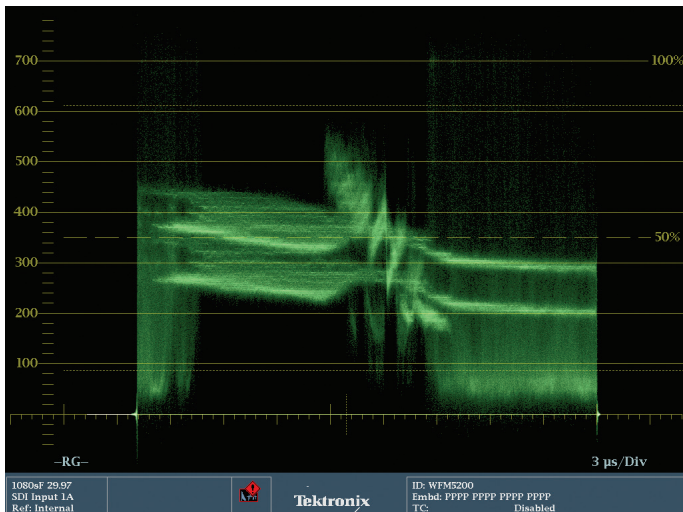


Figure 4-7. The RGB Overlay display of the Coit Tower image with the blue channel turned off.

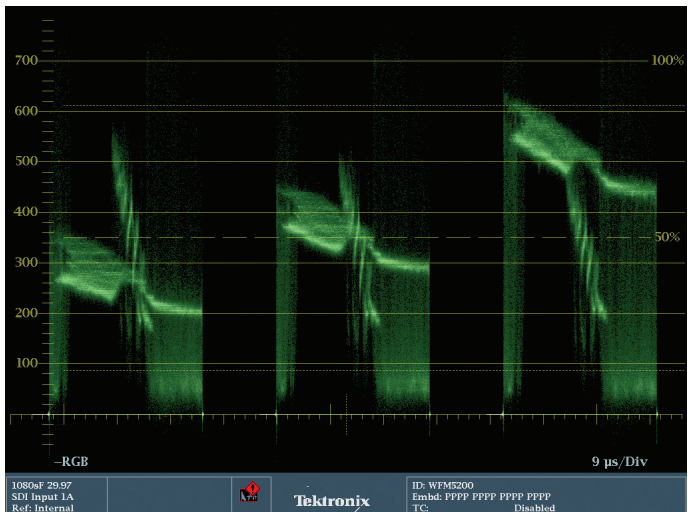


Figure 4-8. Coit Tower as an RGB parade display.

The only real difference in this view for this particular image is that you can see the sky broken down into three distinct horizontal “strata.” Can you guess which layer is which color channel? Since the sky is blue, the blue channel is the upper layer. To confirm this, look at Figures 4-5, 4-6 and 4-7. In Figure 4-5, the red, channel has been turned off, confirming that the red channel was the lowest “strata.” The green channel has been turned off in Figure 4-6 and the blue channel in the overlay has been turned off in Figure 4-7, showing that it was the highest strata. The green and blue channels contribute

to the blue sky because of the brightness and paleness of the sky. If the blue channel was up all the way, and the other channels were not contributing at all, you would have a highly saturated, fairly dark blue sky. If all three channels were at full power, that would create white, so to make a blue that is somewhere between pure blue and white means some combination of equal parts red and green have to be added to the high level of blue in order to make the sky brighter and paler. In summary, here is the complete waveform of the RGB Parade (see Figure 4-8).

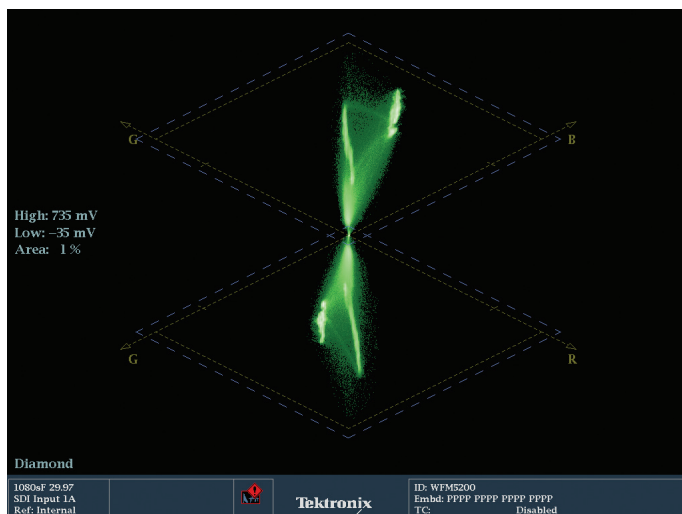


Figure 4-9. Diamond display of Coit Tower.

If we view this same image in the Diamond display (Figure 4-9) we are plotting the Green with the Blue channels in the upper half of the display and the Green with the Red channel in the lower half of the display. We would expect a relatively vertical trace in the upper and lower halves that show a fairly well balance image. The user can see how much headroom is available by comparing the trace to the graticule limits and making adjust to increase overall gain or saturation of the image.

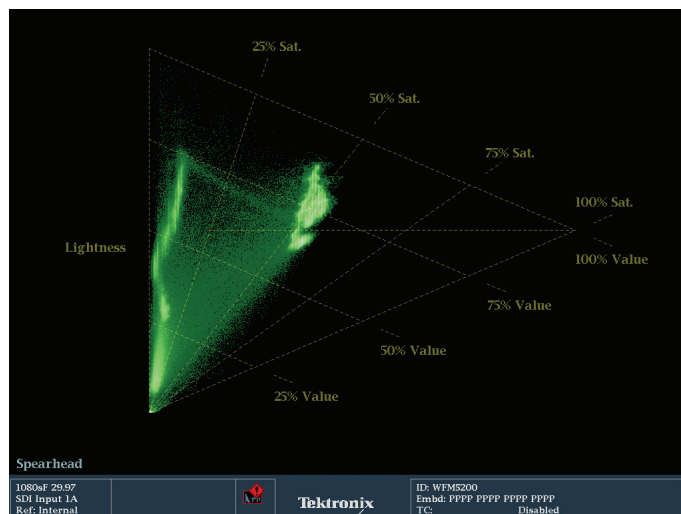


Figure 4-10. Spearhead display of Coit Tower.

If we also view the same image within the Spearhead display we (Figure 4-10) we can also compare the lightness with saturation and value of the image. The Spearhead shows some color cast to the upper part of the lightness on the left side of the trace which is likely from the Coit tower itself. By adjustment of RGB, this color cast could be removed by moving the trace more towards the left hand side and removing the color cast.



Figure 4-11. Marine looking through binoculars.

Here's another example (Figure 4-11).

For this image of a Marine looking through binoculars, the display style in the WFM menu option has been set to (Figure 4-12):

Display Style> Overlay, Display Mode>YRGB, Y>On, R>Off, G>Off, B>Off.

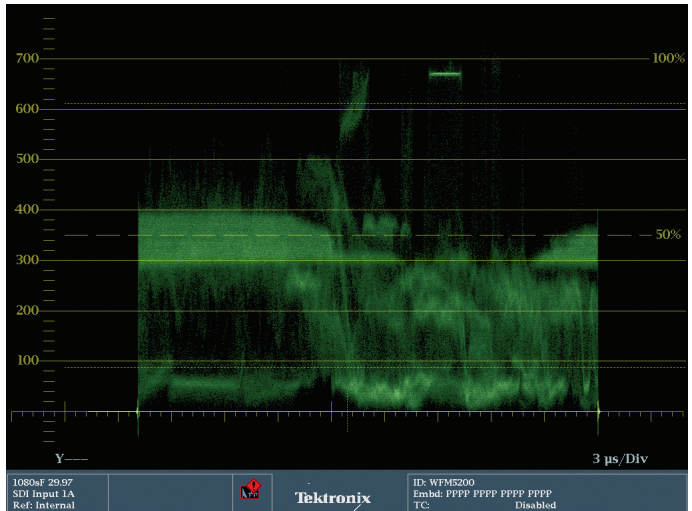


Figure 4-12. Luma only overlay waveform display for Marine with binoculars image.

The thick band on the left side between 300mv and 400mv represents the blue sky. The finer trace above and below it is the highlights and shadows of the mountains. The band of the trace near the bottom of the waveform on the left is the dark case or weapon at the bottom of the image. The two brightest parts of the trace are the lenses of the binoculars. Note that the left lens has some detail in the highlights while the right lens is clipped into a flat line in the trace. There are two other bright areas of the trace. One is the highlight on the knob of the binoculars between the two lenses and the other is the reflection off the metal of the handgrip of the pistol.

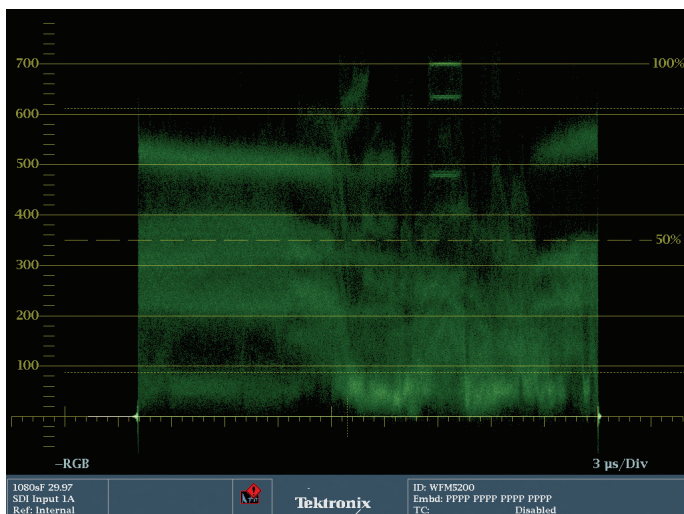


Figure 4-13. RGB overlay waveform display for Marine with binoculars image.

To understand how the color channels interact, we'll change the waveform menu options to (Figure 4-13):

Display Style> Overlay, Display Mode>YRGB, Y>Off, R>On, G>On, B>On.

With this overlay trace, two specific things stand out. The band at the left in the 500mv range is the blue of the sky. Unlike the image of Coit Tower, three color channels are not as visible because this sky is a much deeper, richer blue. The more saturated a primary color is, the more one color channel will stand out from the rest. In the brightest part of the image, the right binocular lens can be seen separated into the three color channels. The brightest (highest) line is the green channel, because the lens reflection is yellow. Perfect yellow is made from equal amounts of green and red. The color of the lens is a more greenish yellow than a reddish yellow. The next line down in the trace is the red channel, and the lowest line in the trace is the blue channel, because blue is the opposite of yellow, so the blue channel is the weakest. Despite this, the blue trace is quite high. That is because the reflection of the lens is so bright. The closer we get to white (bright) the more we need all three color channels to be at full power.

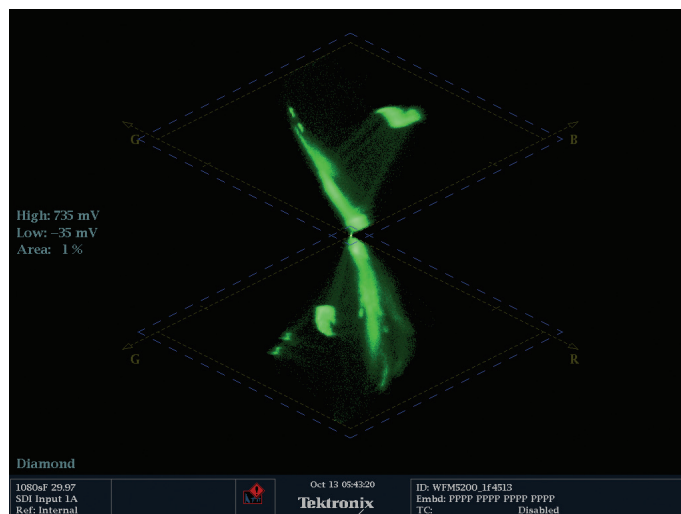


Figure 4-14. Diamond display of Marine.

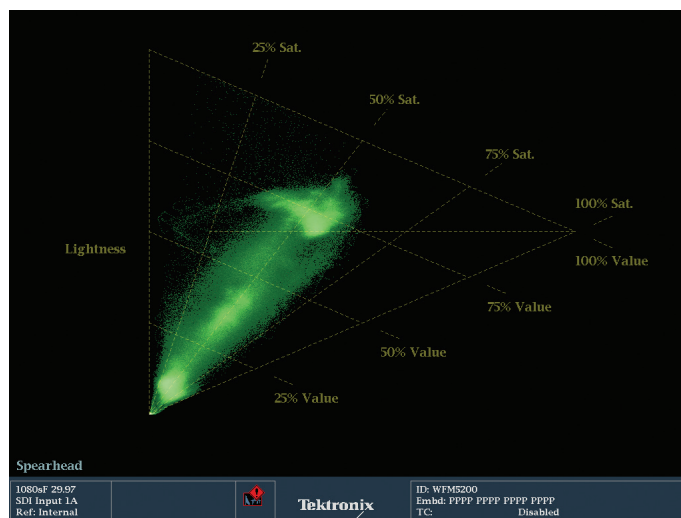


Figure 4-15. Spearhead display of Marine.



Figure 4-16. Footage of a barn. Note the areas of dark shadow; bright, balanced white; and the neutral gray of the roof.

For this image of a barn, (Figure 4-16) we'll switch the trace to:

Display Style> Overlay, Display Mode>YRGB, Y>On, R>Off, G>Off, B>Off.

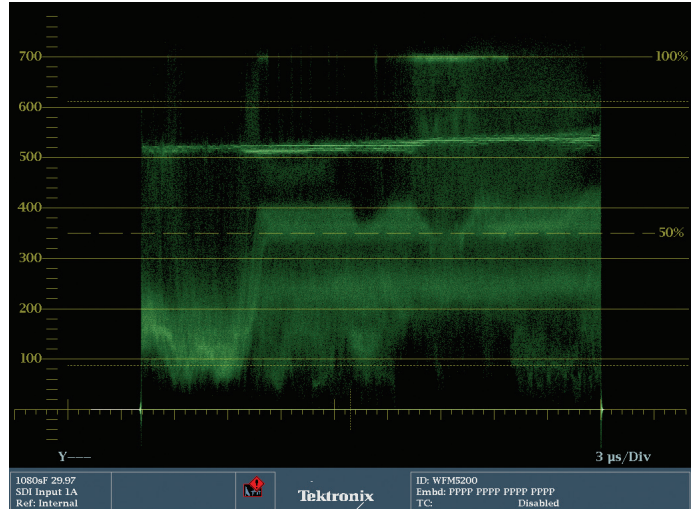


Figure 4-17. Overlay waveform displaying only Y (luma) of the barn image.

Starting from the top of the waveform trace (Figure 4-17), you can see three different areas where the highlights of the cloud have been clipped. Most of the top of the trace, from about 450mv up to 700mv represents the sky. There is another bit of trace near the left side, just above and below the 500mv line that represents the two different brightnesses of the barn roof. All the way across the trace from about 400mv down to 100mv is the trace of the gravel road, grass and mountains. The distinct, sharp part of the trace at about 100mv, just to the left of center is the shadowed area of the barn facing the camera.



Figure 4-18. Line selection has been enabled. Note the “thinness” of the trace. Also note the thin white line horizontally across the middle of the thumbnail, just below the white face of the barn.

One way to confirm the relationship between a specific area of the trace and the image itself is to use Line Select mode, which is accessible by pressing the LINE SEL button. This function only reads a single horizontal line of the image at a time, making it much more clear what part of the trace is coming from a specific part of the image, since the waveform monitor doesn’t normally distinguish different vertical elements in the picture. With the LINE SEL button toggled on, you can change the specific line that is being displayed in the trace with the General dial (Figure 4-18). It is easier to use the Line Trace function if you have a Picture monitor up at the same time or if you have a Thumbnail displayed within the full-frame waveform display (Figure 4-19). To add a thumbnail view:

1. Press the **CONFIG** button to call up the Configuration menu options.
2. Press the up and down arrow keys or use the General dial to navigate the menu choices on the left.
3. Select Display settings.
4. Press the Right arrow key to navigate to the next set of menu choices (with “Readout Intensity” at the top)
5. Use the down arrow keys or General dial to navigate to the bottom choice, “Thumbnail.”

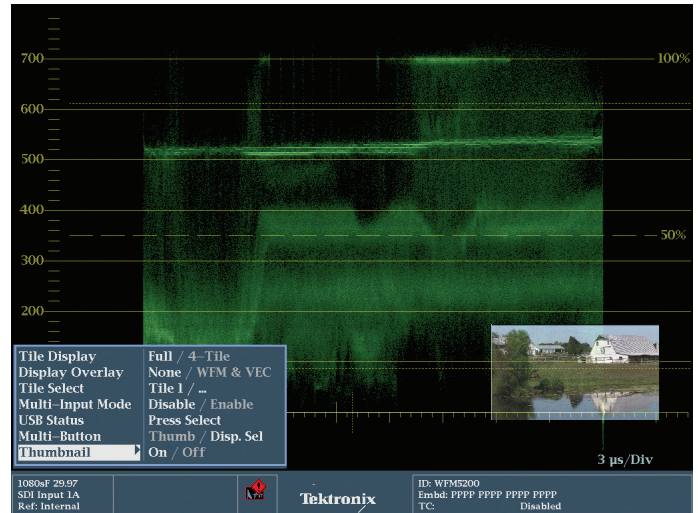


Figure 4-19. This shows the MAIN menu options to add Thumbnails to waveform displays.

6. Press the right arrow key to toggle the Thumbnail selection from Off to On.
7. With the Thumbnail option set to On, a small thumbnail display of the image should appear in the bottom right corner of your waveform monitor.

This thumbnail - or the Picture monitor - will display a white line on the image at the horizontal point you are monitoring with the LINE SEL. You can also see which numerical line you are on with the numerical display. Use the General Dial to move the position of the white line to a specific part of the image in the thumbnail. The trace of the waveform monitor only shows the video levels for the single horizontal line that is indicated by the white line in the thumbnail. This is a much less complex trace pattern because only the information for that line is displayed, instead of the superimposition of approximately 1080 lines on top of each other.



Figure 4-20. This image of the Marine is slightly different than the one used earlier.

Now that you have a sense of basic levels using an “overlay” waveform monitor, let’s look at some additional examples using a Parade waveform monitor. We’ll go back to the video image of the Marine with the binoculars (Figure 4-20).

To switch to Parade mode:

1. Hold down the WFM button for two seconds to call up the waveform menu options.
2. Change the Display Style to Parade. The last image we were looking at already had the Y channel off and the three color channels (RGB) on.

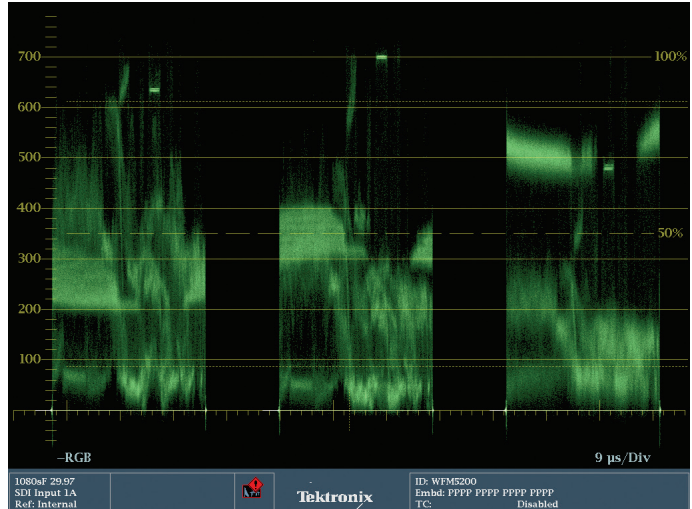


Figure 4-21. This is the representation of the Marine footage in an RGB Parade waveform monitor.

In Parade mode (Figure 4-21), the display is broken down into three separate traces, one each for red (to the left), green (in the middle) and blue (to the right). In the red trace, or cell, the sky is visible on either side from about 200mv to 300mv. In the green channel, the trace for the sky is the band between 300mv and 400mv. And in the blue channel, the sky is represented by the band between 500mv and 600mv.

The binocular reflections can be seen in the middle of the red and green traces between 600mv and 700mv. But the trace in the blue channel representative of the left lens is at about 350mv and the right lens, which is brighter, is just under 500mv. Note that the trace in the right lens in the green channel shows some clipping, seen in the tight line that is formed at 700mv in the trace. The red and blue channels don't clip at all.



Figure 4-22. This uncorrected image of a barn on a farm is not properly balanced.

USING THE WAVEFORM MONITOR FOR BALANCING

With a solid understanding of how to compare elements in the picture with elements in the corresponding trace display, balancing a real world image is a matter of determining what elements in the picture should be white, black or neutral gray and finding those corresponding elements in the trace. Most colorists will prefer to do this in Parade mode, but it is possible to do this in overlay mode as well.

We'll start with this footage that includes a white barn (Figure 4-22). In this footage, there are obviously some parts of the image that are supposed to be white or black. Balancing these should balance the entire image.

Starting with black, looking at the trace (Figure 4-23), there are black levels all along the bottom, especially to the left side, which probably represents the shadows in the tree area on the left. In the image itself, there is a dark shadow just to the left of center where the dark stalls in the center farm building plunge into shadow. To balance black levels using the shadow area in the trees could be dangerous because the blacks there could have elevated levels of green from the leaves which you would not want to correct out. But just trying to balance the overall black levels across the bottom should get good results. The shaded stalls in the middle of the picture should be just to the left of absolute center on the waveform monitor, in the green channel. Trying to balance that black level across all three channels should also get a good result (Figure 4-24).

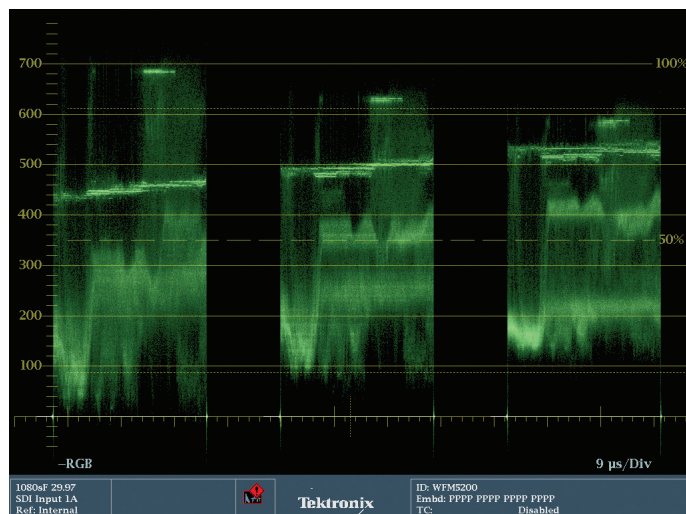


Figure 4-23. This is the RGB waveform representing the uncorrected barn footage. Note that the highest and lowest levels of the trace in the red, green and blue channels are uneven.

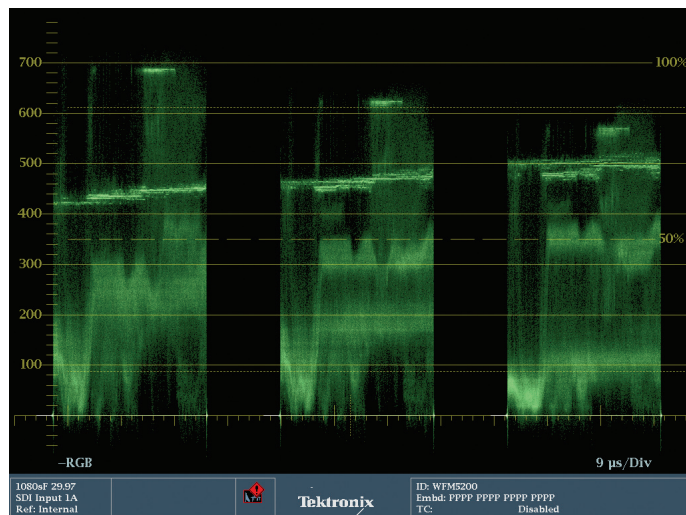


Figure 4-24. Note that the levels across the bottom of all three color channels is now even, compared with Figure 4-23.

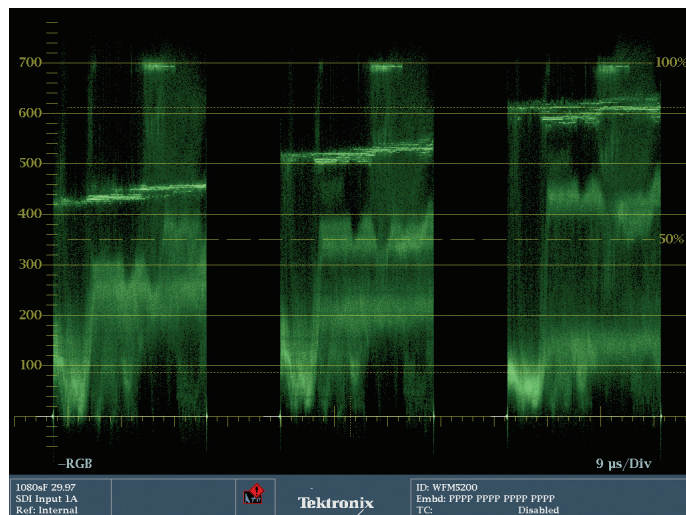


Figure 4-25. Corrected RGB parade of barn shot.

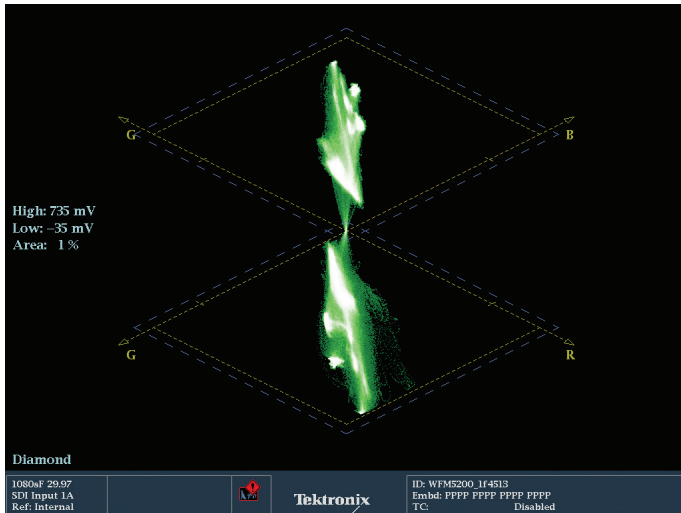


Figure 4-26. Diamond display of uncorrected Barn image.

To balance for highlights, the face of the barn, just to the right of center is an obvious choice. The white in the face of the barn is just slightly clipped. If the white had been more severely clipped, the face of the barn would not be a good choice because clipping can affect one color channel more than another, so a clipped signal is sometimes deceiving to balance to. In this case, the sharp line of trace along the top isn't too sharp and compressed, so it should be a true indication of balance between the channels. To balance this image simply raise all three channels to the same level along the 700mv line (Figure 4-25).

The Diamond display can be used to make the same type of adjustment. The trace does not have a vertical component and is offset with a deviation towards green in the upper trace and a deviation towards red in the lower trace as shown in Figure

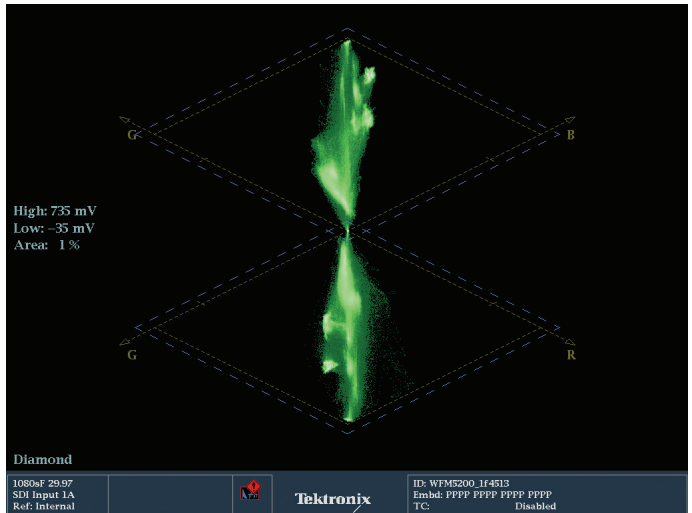


Figure 4-27. Diamond display of corrected Barn image.

4-26. Start by adjusting the black so that the two deviating traces meet in the middle of the display firstly adjust the Green black control which should move both upper and lower traces more towards the center. Then adjust the black of the blue component until it is also center in the middle. Adjustment of the blacks for red can be made to ensure the traces touch together and are center. Once the blacks have been adjusted we can focus attention on the highlights, adjust the RGB gain such that the trace has a more vertical line to the display by first adjusting the G gain and then B gain such that the upper traces is more vertical and aligns with the upper apex. Then adjust the R gains until the lower trace aligns more vertically to the lower apex, and the image resembles Figure 4-27 of the Diamond display. By becoming familiar with the Diamond display you will easily be able to identify the components in error quickly and make adjustment to balance the image.

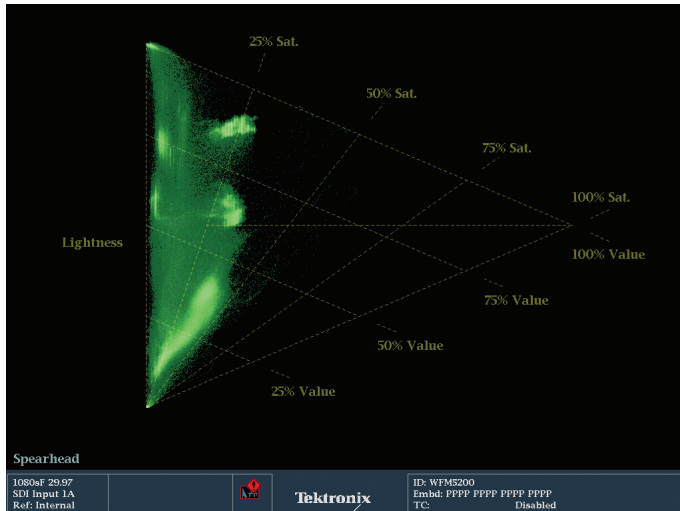


Figure 4-28. Uncorrected Barn image shown within Spearhead display

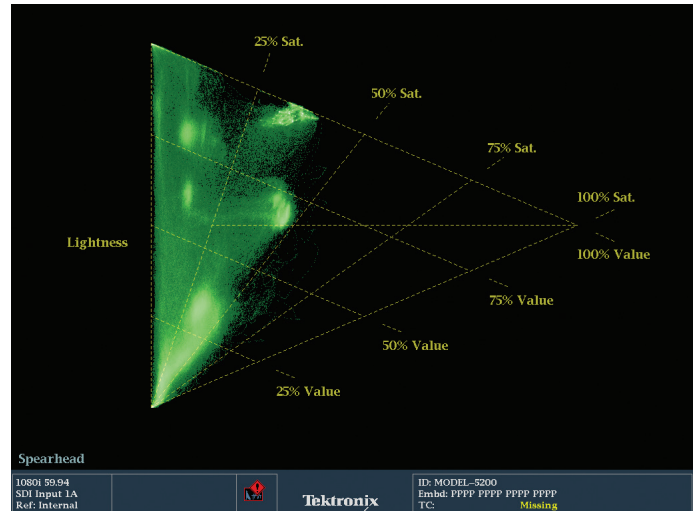


Figure 4-29. Spearhead display of corrected Barn image.

Since this image has a strong white luma content from the barn within this image you may wish to ensure that there is no color cast to the whites within this image. The Spearhead display can be used to check for this, by ensuring that the trace forms a strong vertical component along the lightness axes. Figure 4-28 shows the uncorrected image, notice the deviation from the vertical axis. While you cannot identify the component in error as easily within the Diamond display you can make fine adjustment of the color correction controls to push the trace more towards the left hand side and remove any color casts that may have been present within the image as showing in Figure 4-29.

There is a straight line of the trace that goes across all three levels at about the 450mv mark in the red channel, the 550mv level in the green channel and the 600mv level in the blue channel (Figure 4-30). This misbalance is fine in this case because this line is representative of the blue sky, so the blue channel should be the highest and the red channel should be the lowest as we've seen in several other investigations of images with sky in them.

Setting a midtone balance at this point probably doesn't need to be done, since the highlight and shadow balance has brought the image to a pleasing place that looks true. A tip to balance midtones could involve isolating a midtone gray level using tools in an NLE, an external switcher or the zoom function of some color correction application. Each application

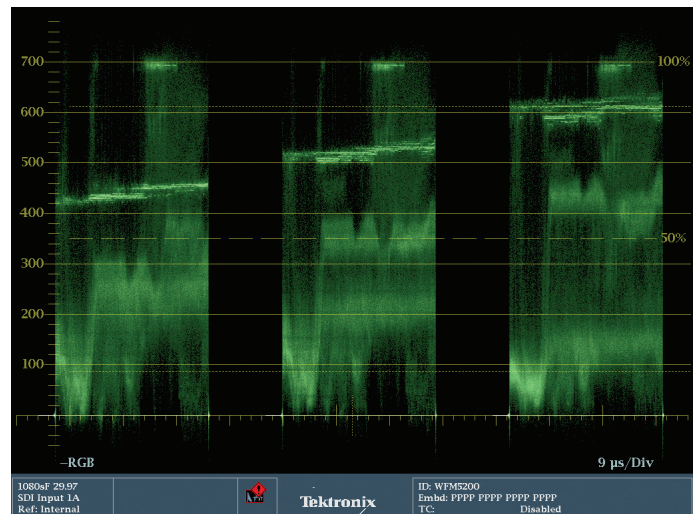


Figure 4-30. Note that the levels across the top of all three color channels are now even. The differing levels in the 400mv to 600mv range are due to the blue of the sky and reflection of the sky in the water, so blue should be the strongest channel in that range.

will be different, but the idea is the same: crop or zoom all the way in to a portion of the image that contains the portion of the image that you want to balance. This isolates that color from all of the surrounding elements. In this example, a crop has been placed on the image to isolate the gray corrugated steel of the barn roof. The trace in this case is well balanced, with all three color channels being approximately equal. This tip can also be used with shadows and highlights.

CHECKING BALANCE IN THE DIAMOND DISPLAY

Similarly you can use the Diamond display to balance the black and whites of the image. Starting with the split Diamond display it is easy to see the blacks at the center of the screen and make adjustment of the RGB controls until the black levels are equally balanced. Then determine as before that there is a white part to the image and adjust the controls of RGB until a straight line vertical from the center to the upper and lower apex of the Diamond is formed. With the barn image now balanced for black and white within the Diamond display, there are numerous tones and colors in the image, including green tones in the grass and blue tones in the sky and water, the majority of the image still balances nicely right through the middle of the Diamonds, indicating a good balanced image (Figure 4-27).

Vectorscope

The vectorscope analyzes hue and saturation. The vectorscope is a good indication of color balance and can be used very easily with the trackballs or color wheels in color correction applications. There is no indication on a vectorscope of luminance or which luminance ranges contribute to the trace. When adjusting the shadow, midtone and highlight trackballs, the trace on the vectorscope react very intuitively. For example: Roll one of the trackballs or color wheels up and to the left and the trace on the vectorscope will move up and to the left.

Many aspects of color theory are represented on the face of the vectorscope as shown in chapter 1 Figure 1-7. The targets for red, blue, and green form a triangle. These are the primary

colors. In between each of these primary colors are the colors formed by mixing those primaries. The color between red and blue is magenta. The color between blue and green is cyan, and the color between red and green is yellow. These secondary colors form another triangle. Sometimes you will want to manipulate or eliminate a color that is not a primary color. Without a specific color channel to manipulate to adjust those secondary colors, the color relationships on the vectorscope provide the clue. Yellow is equal amounts red and green. Magenta is equal amounts red and blue. Cyan is equal amounts blue and green.

Another beneficial relationship that can be seen is that certain complementary colors are directly opposite certain primary colors. Red is opposite cyan, magenta is opposite green, and yellow is opposite blue. These relationships help to see that if an image is too magenta, you can add green, which is its opposite. If an image is too blue, add its opposite: yellow. And an image that is too cyan can be corrected by adding red.

For balancing images, perhaps the most important and possibly least intuitive relationship is that white, black, and pure grays should all sit neatly in the center of the vectorscope. While most video images will have a range of colors, they also usually have some amount of whites, blacks, and neutral grays. The key is to be able to see where these parts of the picture sit on the vectorscope and then use the color correction tools at your disposal to move them toward the center of the vectorscope.

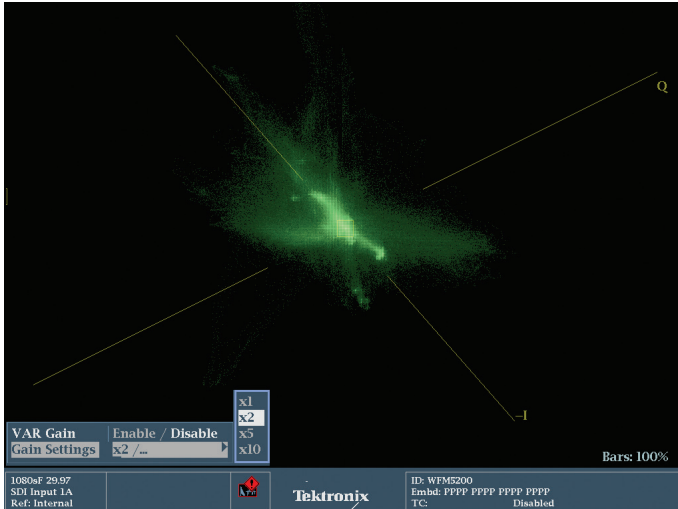


Figure 4-31. The GAIN button allows you to zoom in on the center of the vectorscope. There are actually controls to zoom in on any of the specific color targets on the vectorscope, but zooming in on black is the most common and useful choice.

When trying to balance colors using a vectorscope, it is sometimes helpful to zoom in to the center of the vectorscope. On the WFM5200 and other Tektronix waveform monitors, the amount of “zoom” on the vectorscope is determined by the GAIN button. Pressing it quickly will jump in to a specific, preset amount of zoom. The default is 2x, but it is possible to adjust this:

1. Hold down the **GAIN** button for 2 seconds and the GAIN menu commands will come up.
2. Use the down arrow to move to the Gain Settings option.
3. Use the right arrow key to move over to the numeric gain amounts.
4. Use the up and down arrows or the General dial to select one of the options (1x, 2x, 5x, 10x).

2x and 5x are the most popular and useful choices. 10x is very detailed, but minor adjustments at this zoom level will take the trace off the screen. There needs to be a balance between seeing detail and having an overall sense of where the trace is on the face of the vectorscope. If you like the higher zoom amounts (GAIN), it might be wise to set a preset with two vectorscopes side by side: one set to normal gain (1x) and the other set to a higher amount. For more on creating presets, see section 6 of this Primer.

With the vectorscope zoomed in, it is easier to see the brighter parts of the trace that are near the center. Adjusting the shadow, midtone and highlight color wheels or trackballs while looking at the display will give a good idea of where the neutral portions of the trace need to be. Obviously the entire trace can't be centered. Green grass in the trace should head towards the green vector, blue sky will head up towards the blue or cyan vector and warm tones will head towards red or yellow. Additionally the Luma Qualified Vector can be used to isolate the blacks or white luma levels within the vectorscope to help isolate these luma levels within the vectorscope display as discussed in the section in chapter 2 titled “Introduction to the Luma Qualified Vectorscope”.

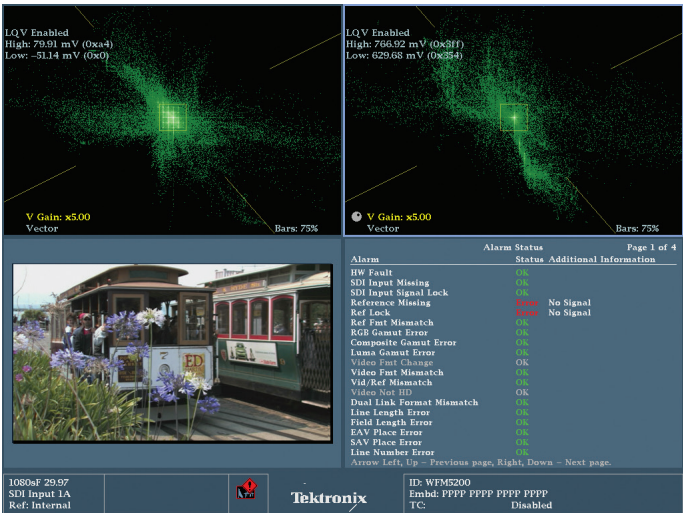


Figure 4-32. This preset for the WFM5200 has two LQV displays. The one on the left is set for the darkest 10% of shadows. The one on the right is set for the brightest 10% of the highlights. Both displays have GAIN set to 2x to focus on the center (black) of the vectorscope, making it easier to dial in the black balance.

BALANCING IMAGES USING LUMA QUALIFIED VECTORSCOPES

Section 2 of this Primer describes the set-up and theory of Luma Qualified vectorscopes.

In this section we'll see how to use a pair of LQV displays to balance colors. This image of streetcars in San Francisco has a little of everything. The red frame of the windows in one of the trolleys is clearly visible in the trace as it extends well out towards the red target. The blue flowers in the foreground are represented with the trace extending towards the blue target. The desaturated yellow and brown tones are probably the trace that extends just a small amount towards yellow, just under the -I line. The greens of the flowers are very desaturated and fairly yellow and represented by a bright blob of trace on the

horizontal line heading slightly just below the yellow target. The green color on the sign on one of the trolley cars is dark, desaturated and actually closer to dark cyan than dark green. It barely extends past the center of the vectorscope. The street itself is very desaturated but is a bright, warmish flesh tone that also extends along the -I line, but not very far from the center.

Within this image it is very hard to detect where black and white were in the trace because of the additional colors in the scene. With our preset LQV displays only showing us the brightest 10% of the image and the darkest 10% of the image, the trace displays are much easier to see (Figure 4-32).

The most intuitive way to adjust the black and white levels with LQVs is to use the highlight and shadow color wheels or trackballs. The shadow trackball was adjusted while watching the LQV set to exhibit shadows (LOW: -51.14 HIGH: 70.32). Moving the color wheel or trackball in any direction moved the trace in the display the same direction. The goal was to center the brightest part of the trace directly in the center. Sometimes it is useful to have the GAIN on to better judge the exact center of the display.

With the blacks balanced, the highlights were then adjusted with the highlight trackball or color wheel while watching the LQV set to exhibit highlights (LOW: 630.48mv, HIGH 766.32mv). Centering the trace in the LQV display balances the highlights.

The operation of LQVs is identical to a regular vectorscope, but the ability to isolate specific tonal ranges, especially those that correspond to color correction controls, makes balancing much easier.



Figure 4-33. San Francisco Town Hall.

FLESH TONES ON A VECTORSCOPE

Flesh tones are critical in color correction because everyone knows instinctively how these should look. Despite racial color differences in skin tones, the trace of a skin tone will end up very close to the -I line on an SDI/Composite vectorscope graticule (within 10 or 20 degrees). This makes sense because skin tones are slightly reddish, slightly yellowish and the -I line (sometimes called the “flesh tone line”) is between the red and yellow targets on the vectorscope. The top quarter of this line, which runs from about the eleven o’clock position to about the five o’clock position, is widely accepted as the line where skin tones should fall.

Feed an image with a large amount of skin tones into your vectorscope and notice how it lines up on the -I line. The -I line is not a hard and fast rule with skin tones. There are actually regional preferences to skin tones in various countries around the world.

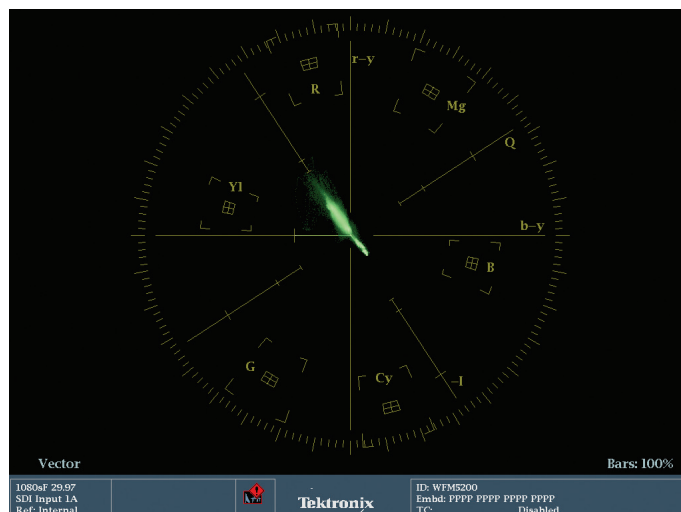


Figure 4-34. This is the vectorscope image representing the footage in the clip of San Francisco Town Hall. Note that the trace extends up the -I line and down towards the blue/cyan targets.

Comparing the trace of the vectorscope to footage

This image is of San Francisco’s Town Hall. The image is primarily warm tones of the building contrasted with the cool tones of the sky. Note that the trace lines up right along the -I line (Figure 4-34). The building is a yellowish/reddish color and the sky is cyan. Despite these strong tones, the black tones are perfectly centered in the vectorscope.



Figure 4-35. Marine with green highlights.



Figure 4-37. San Francisco cable cars.



Figure 4-36. This is the vectorscope image representing the footage of the Marine with binoculars. Note the two small dots extending towards the green trace. These are the two green reflections on the lens of the binoculars. The trace showing the warm flesh and earth tones and the blue of the sky are also clearly visible.

This image (Figure 4-35) is a slightly different frame of the Marine that we used earlier. Notice the angle on the binocular has caused the lenses to become green. The green lenses are clearly visible in the trace as two dots that extend out in the exact direction of the green target on the graticule (Figure 4-36). The warm skin, clothing and mountain vista are bathed in warm sunset tones causing the trace to head fairly strongly up the -I line towards the red and yellow targets. The rich, blue sky causes the trace to extend out further than the Town Hall sky, indicating the saturation.



Figure 4-38. This is the vectorscope image representing the San Francisco streetcars.

With all of these images, even though portions of the trace extend in various directions, the bulk of the trace is perfectly centered in the graticule, indicating that all of these images are well balanced.

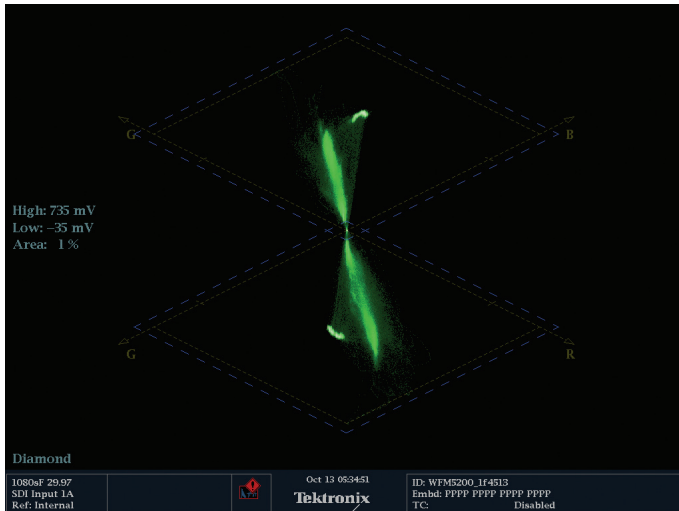


Figure 4-39. Diamond display of uncorrected San Francisco Town Hall.

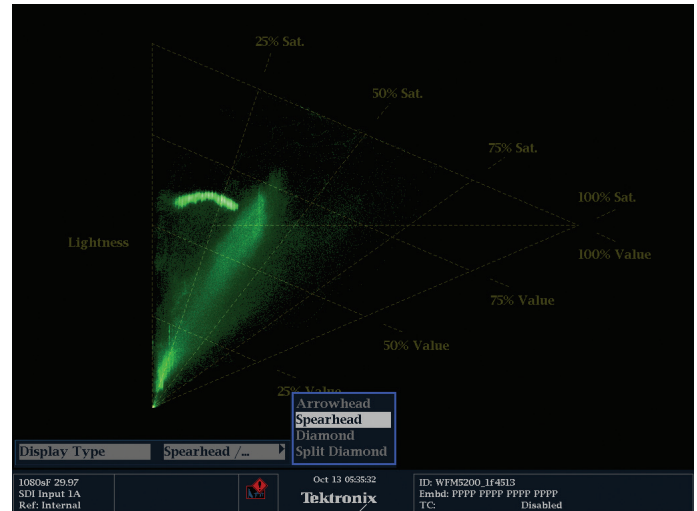


Figure 4-40. Spearhead display of uncorrected San Francisco Town Hall.

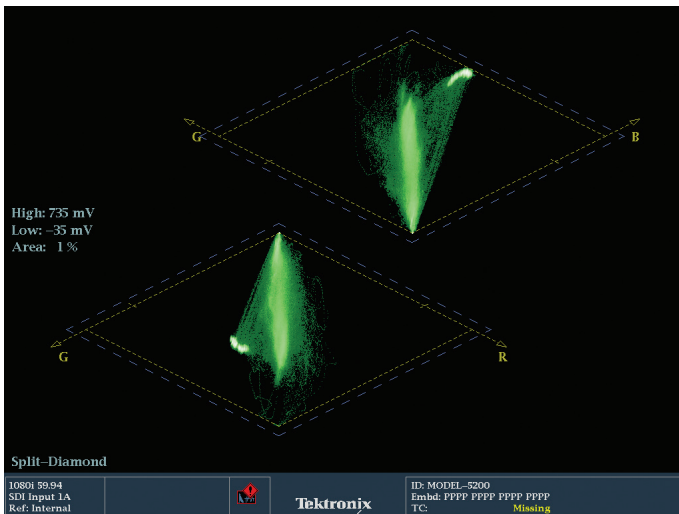


Figure 4-41. Diamond display of final corrected San Francisco Town Hall image.

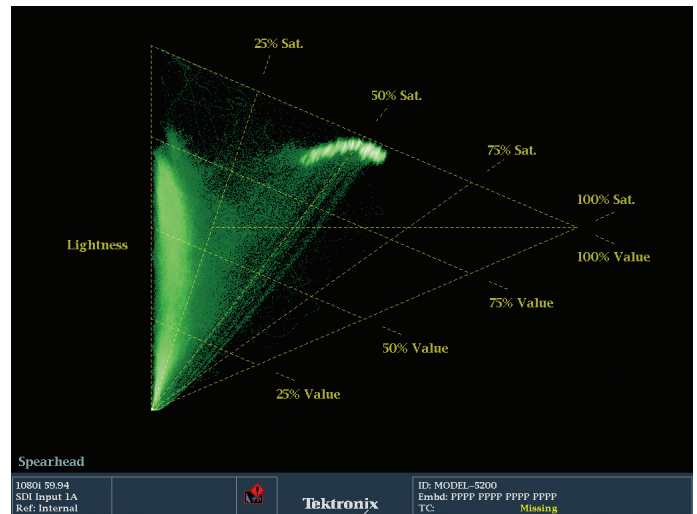


Figure 4-42. Spearhead display of uncorrected San Francisco Town Hall.

Grayscale tracking using Spearhead and Diamond displays

In some cases we may want to remove the color cast from an object or scene and the Tektronix Spearhead and Diamond displays can be useful for performing grayscale tracking. In the Diamond display the luma of the signal is present in the vertical axes from the center to the outer apex and each component can easily be identified. The Spearhead display is an overlay of all components with the lightness (equal RGB components) shown on the left hand vertical axis. Therefore color components will move the traces away from this vertical axis and if we want to remove color casts from a scene then we would adjust the traces until it was aligned with the vertical axis and was more color neutral. Let's take a look at this using the San Francisco Town Hall image (Figure 4-23) instead of the

sandy orange tones of this building we wanted it to look more neutral gray.

Therefore let's view the Diamond display (Figure 4-39) and Spearhead display (Figure 4-40) of this original image and you can see that the traces are deviating from the vertical axis. By adjustment of the RGB controls of the editing system the blacks and gain controls are changed using the Diamond which set the overall dynamic range of the image. The Spearhead display is used to push the trace more towards the left hand edge by adjustment of the color corrector controls. You may have to cycle through each color component once or twice to get the best match and a more neutral looking image as shown in Figure 4-41 and Figure 4-42. The final resulting image of the Town Hall is shown in Figure 4-43.

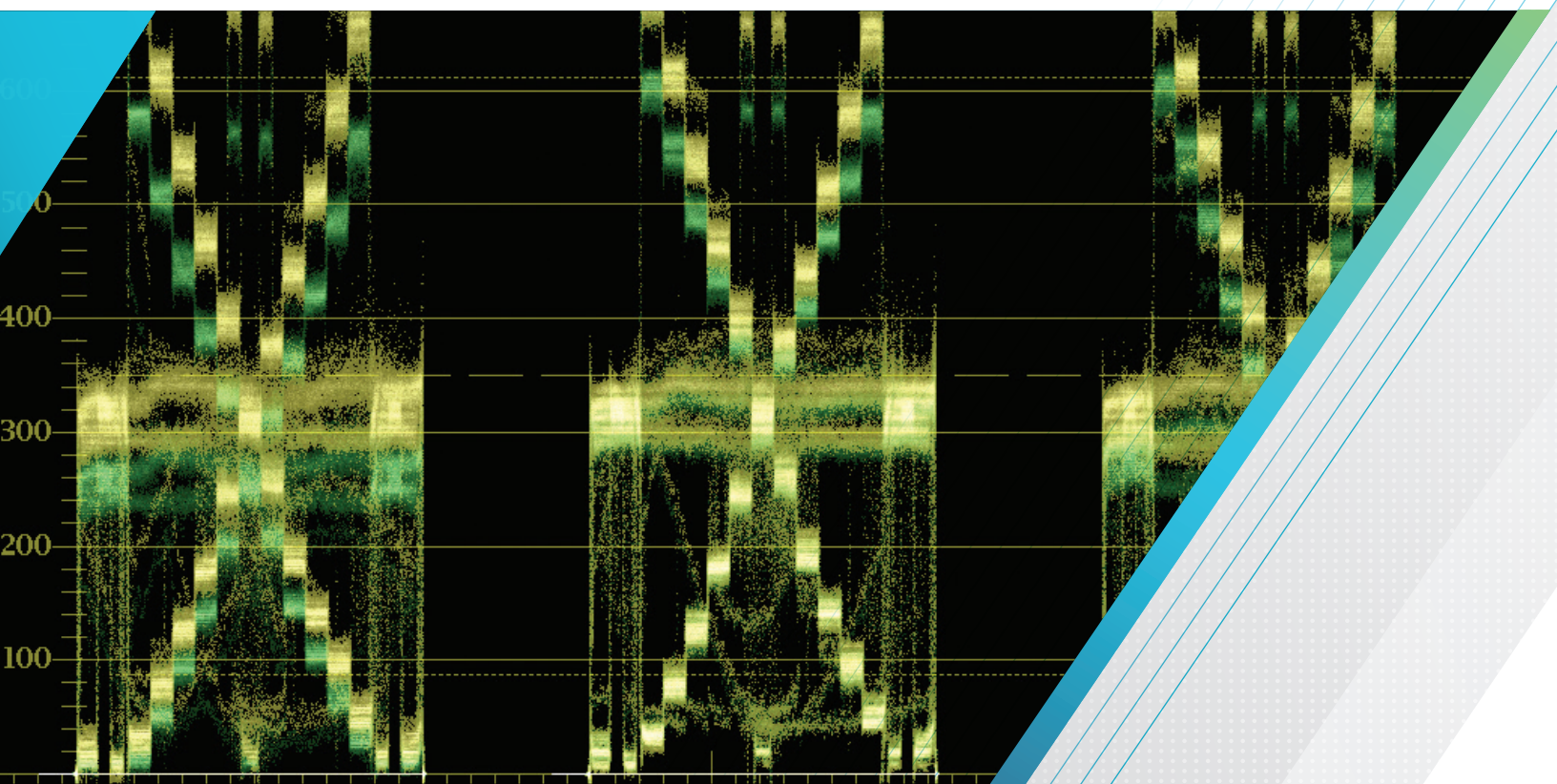


Figure 4-43. Corrected San Francisco Town Hall.

To learn more, watch this tutorial on [Using Waveform Monitors as an Artistic Tool in Color Grading](#).

Section 5:

Scene Matching



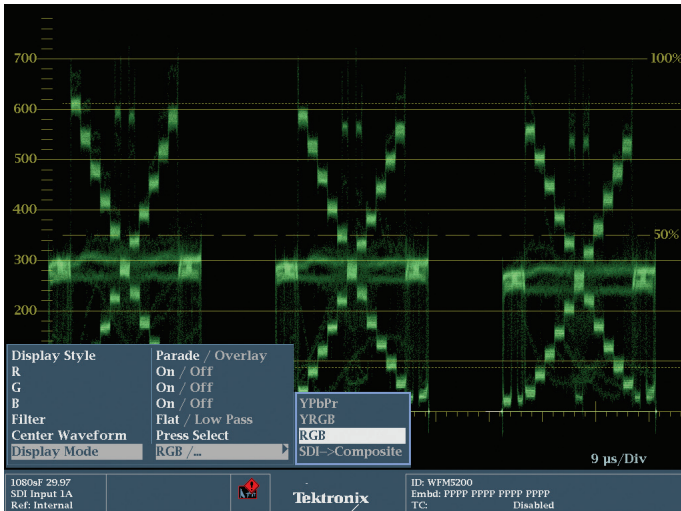


Figure 5-1. This shows the results of steps 1-4.

Section 5 Scene Matching

MATCHING SHOTS

Much of the work of a colorist is highly subjective, but the one area where a colorist has to deliver real objective results is in the task of scene matching. All footage in dramatic TV shows, comedies, features and even corporate and marketing projects require the colorist to make two shots in a scene look like they belong together even if they were shot by different cameras or at different times of day.

The normal method for matching scenes calls for the colorist to save a still of one image that they're trying to match and then cut rapidly back and forth between the reference scene and the scene they're correcting or to wipe between the two scenes.

But, with a Tektronix waveform monitor, there is an amazing little trick that will save time and will get your footage to match very quickly with much less effort. We will do two different matches. One will utilize chip charts and the other will utilize a pair of real-life images.

CHIP CHART MATCH EXAMPLE

It is fairly common for two cameras shooting the same scene to look slightly different, even after a white balance or some other basic camera set-up.

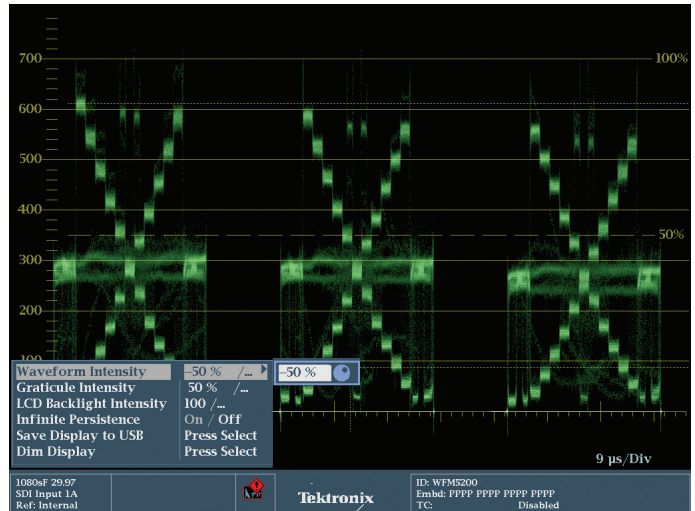


Figure 5-2. This shows the results of steps 5-9.

Before doing the match, it is best to create a preset that works best for this tip.

1. Switch the waveform monitor from displaying four quadrants of information to only one by holding down the Thumbnail button for two seconds. This toggles from four quadrants to a single quadrant.
2. Press the WFM button to call a waveform monitor into the display, replacing whatever was there initially.
3. Hold down the WFM button to call up the waveform menu options.
4. Switch the Display Style to Parade. Make sure the R, G and B channels are selected as ON, and make sure the Display Mode is set to RGB (Figure 5-1).
5. Press the WFM button again to save the changes and dismiss the RGB menu.
6. Press the DISPLAY button to call up the Display menu.
7. Select the Waveform Intensity option.
8. Press the right arrow button to move to the numerical options.
9. Use the General dial to minimize the brightness of the trace. -50% is the minimum (Figure 5-2).
10. Press the DISPLAY button again to dismiss the menu and save your changes.
11. Use the instructions from Section 2 of this Primer to save this as a Preset.

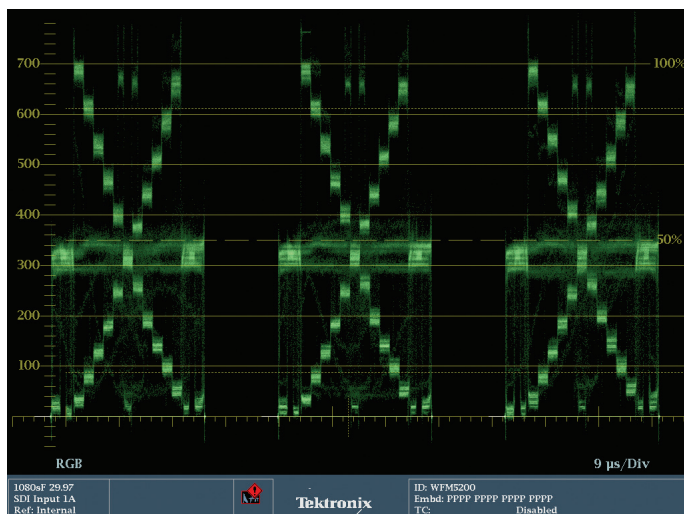


Figure 5-3. This is the trace representing our “hero” grade. The balance and contrast are good.

The reason for this preset is that, for this tip, it’s important to have a good overall view with great detail of the waveform monitor. Trying to do this with four quadrants up is much more difficult. Also, as you will see in a moment, this tip basically doubles the brightness of the display, so turning down the Waveform Intensity makes this easier to see the fine details of the trace.

To begin matching two grayscale charts, the one closest to being correct was chosen and then corrected to deliver our “hero” grade (Figure 5-3). This is the grade we will use to match the other shot.

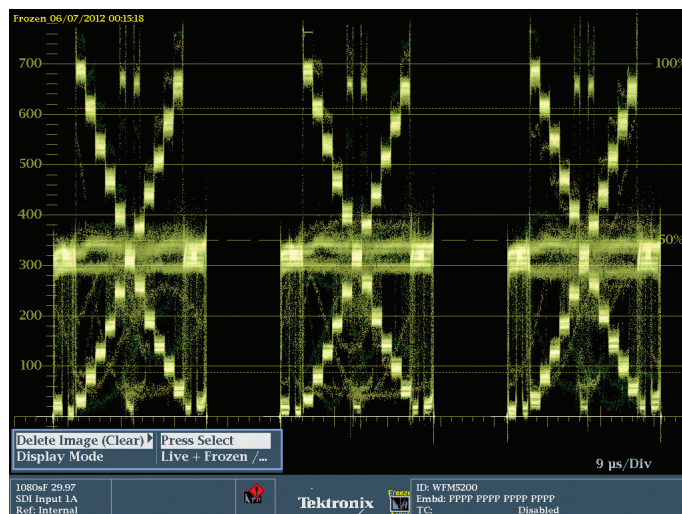


Figure 5-4. The “hero” grade after the Capture button was pushed. Note the color and brightness difference from the previous figure.

With the first camera looking good and fed into the Tektronix waveform monitor, the CAPTURE button on the front lower right side of the WFM5200 was pressed. When this button was pressed, the trace changed color and the exposure seemingly doubled. That is because a freeze of the trace has been stored and colored gold, while the live video image being fed into the WFM 5200 is generating a separate green trace on top of the gold “captured” trace (Figure 5-4).

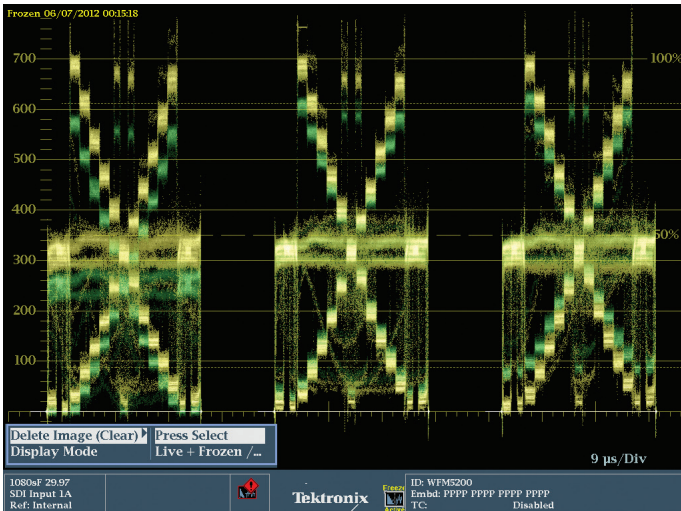


Figure 5-5. The “hero” grade (represented in gold) and the shot we intend to match (represented in green) are laid over each other. Note the differences between the gold and green trace.

In a color grading application, we move in the timeline to the chip chart image of the second camera. Now, instead of perfectly overlapping green and gold traces, you can see camera 1’s trace as gold and the uncorrected camera 2’s trace as green (Figure 5-5). (If you have changed your presets so that the trace is white or some other color, then camera 2’s trace will be that color instead of green, which is the default.)

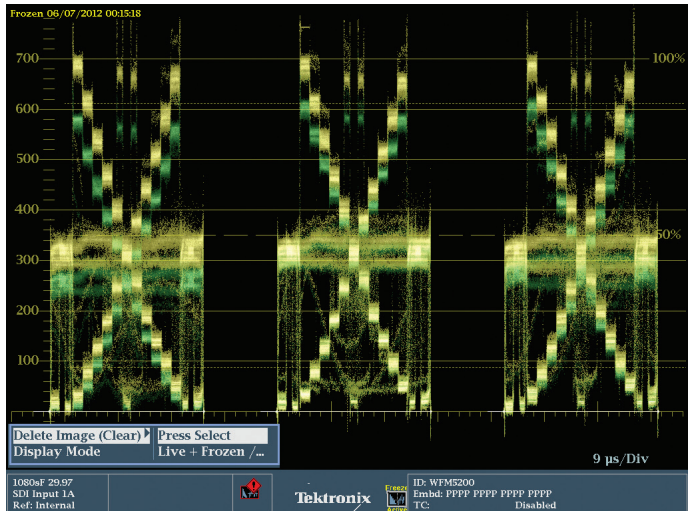


Figure 5-6. This trace is similar to the one in the previous Figure, but the black levels all match across the bottom.

With the two chip chart images overlaid on each other, the goal is to match the trace displays so that the green and gold overlay each other as closely as possible.

Analyzing the match, the red gamma appears to be too low. The blacks in the blue channel are too high. And the overall level appears to be too low.

Use individual red, green and blue controls for the shadow, mid-tone and highlight ranges to try to match the two traces. Another way to do this would be to use Curves for the individual color channels.

As usual, start with the black levels. The red channel looks low, but that could be because of the gamma being so low. Set each black level for each color channel so that the bottoms (shadows) are equal, matching the green to the gold trace.

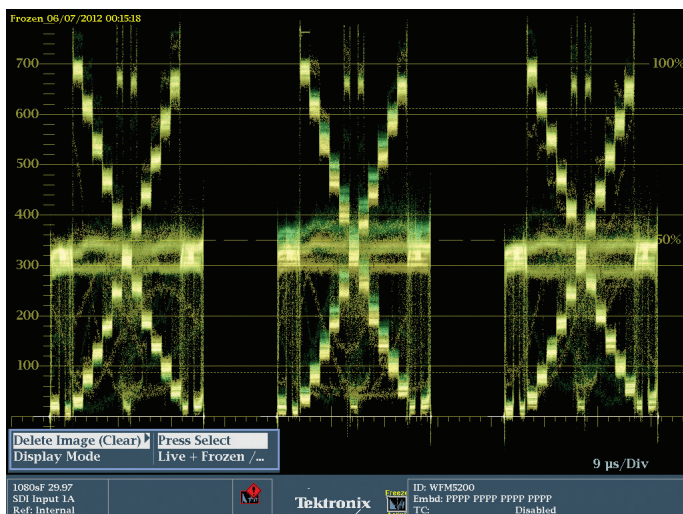


Figure 5-7. This trace shows the effects of the balancing of the highlights. The green gamma still doesn't quite match.

Next adjust the highlight levels of the red, green and blue channels so that the top (highlights) match equally (Figure 5-7).

Finally, use the gamma or mid-tone controls in the red, green and blue channels to match the mid-tones. With this chart, that means the wide double line that sits at approximately the 400 mv mark should match across the two cameras (Figure 5-8).

Because the controls for highlights, mid-tones and shadows are fairly interactive, it is smart to do some fine tweaking of the levels in highlights and shadows again, especially if you're not working with a control surface like the Avid Color or Tangent Devices WAVE or Element. With a control surface, it is easier to move two tonal ranges at the same time, saving time and effort.

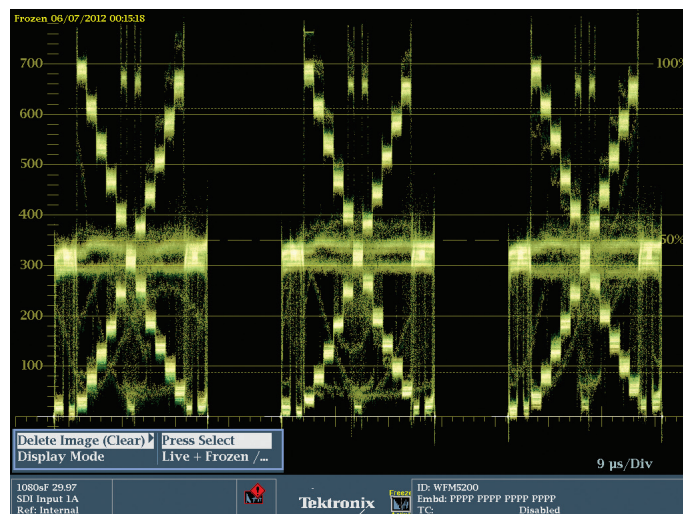


Figure 5-8. This is the trace with the final grading made. Note that the green and gold trace overlay each other very closely.

When the gold and green traces overlay each other perfectly, the cameras are matched. Hit the SEL button (between the arrow keys) to leave Capture mode and return to the standard green trace. If the Capture menu is not on-screen, hit the CAPTURE button again to bring up the menu and the SEL button to leave Capture mode.

To check the match, move in the timeline between your two cameras. If you see a difference in a specific tonal range or color channel when cutting back and forth, tweak it slightly. It might be good to save the grade that was done with Capture before doing any tweaking, so you can get back to the original grade.

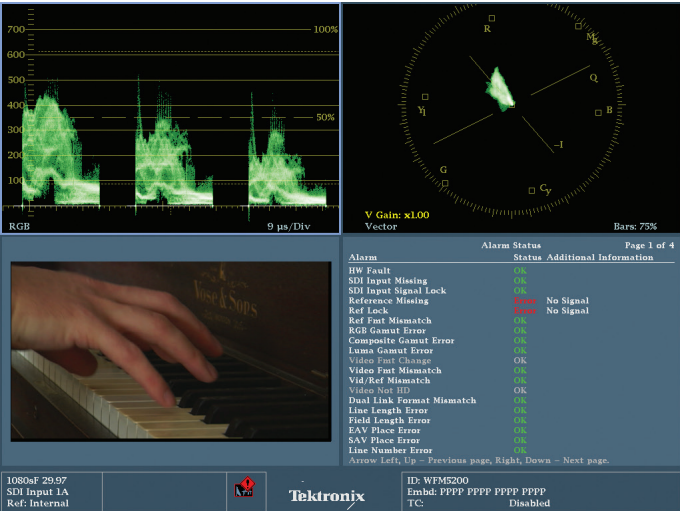


Figure 5-9. The starting point of the “hero” shot.

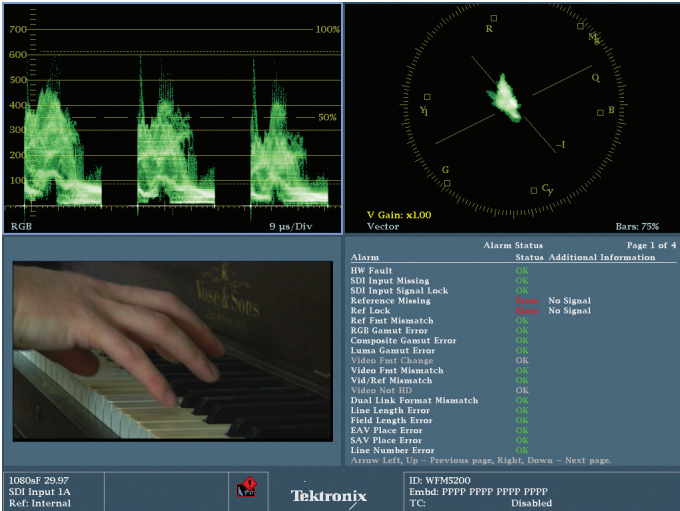


Figure 5-10. Final “hero” grade on the warm, original footage. Overall gain has increased. Red pulled out of the mid-tones. Blue increased in the highlights.

REAL WORLD MATCH EXAMPLE

Colorists rarely get chip charts shot for every scene or shot, so being able to do these matches with a regular video image is critical. The process is essentially the same. We’ll present two different examples. One example where the camera is at the same position, but has two different white balances, and another where the shots themselves are different and have to be matched.

To begin, the first shot that we will be matching to must be corrected to the place that it is pleasing (Figure 5-9). There’s no sense matching to a shot that’s not good to begin with. The warm version of the shot was a little dark and a little too warm, so the overall gain was increased to get the brightest white to 100% and the red mid-tone levels were decreased to bring the hand and the white keys to a more balanced level (Figure 5-10). The RGB waveform shows what appears to be a mis-balance in the mid-tones , with the red channel the highest, followed by green, followed by blue, but in the mid-tone of a shot that has a lot of skin tones, this is natural, because skin tones should have that exact same balance with red the strongest and blue the weakest.

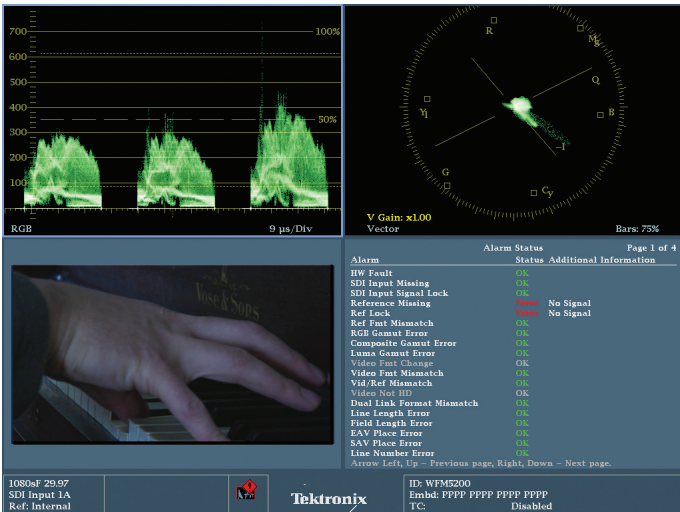


Figure 5-11. This is the starting point of the shot that will be matched to the “hero” shot. Note the much cooler tone, indicated by the blue channel higher than the red and green channels.

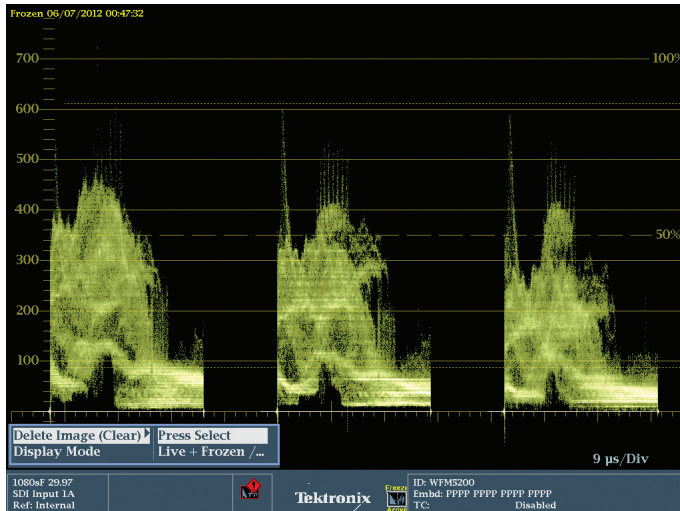


Figure 5-12. The “hero” grade after the CAPTURE button was pressed, overlaying a “live” green trace on top of the “captured” gold trace.

With the main camera set to a proper level and balance, it's time to match the other camera to it. Before calling up the second camera, hit the CAPTURE button, as we did with the grayscale image. The trace becomes a bright blend of green and gold (Figure 5-12).

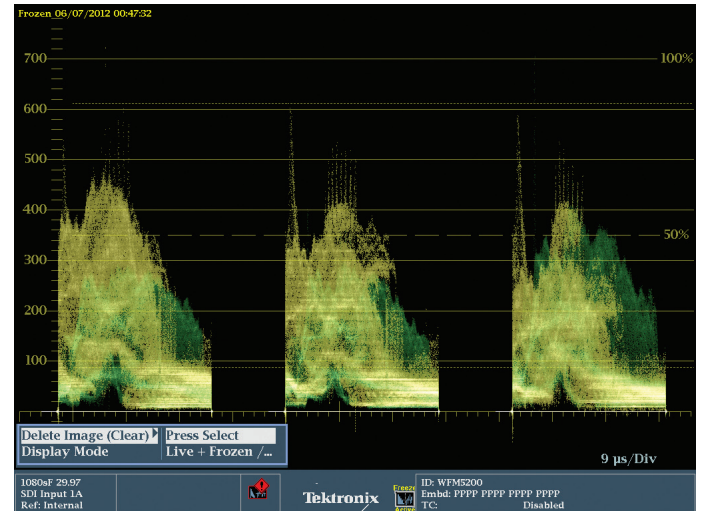


Figure 5-13. The “hero” grade in gold is overlaid with the green “live” feed which is fed by the shot we are matching to. The matching shot is much cooler and darker than our “hero” grade. The waveforms will not match exactly because the fingers are in different locations in each shot.

In the color grading or NLE software, we navigated in the timeline to feed the second camera to the waveform monitor (green trace is “live”). The green and gold traces are different between these two shots because the fingers are in a slightly different position, but it is still possible to see the differences in the trace (Figure 5-13). The second camera is much cooler over all, stronger in the blue channel and weaker in the red channel.

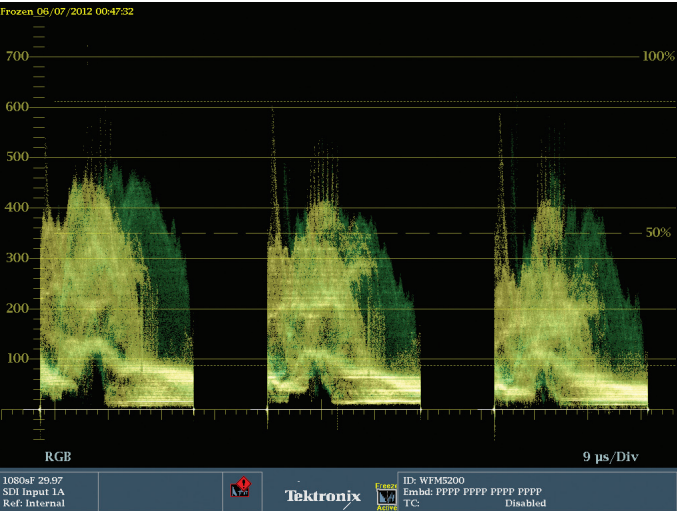


Figure 5-14. The red and green gain was increased significantly to match the overall luminance level and to warm the image to match the “hero” grade.

Use the red, green and blue controls for shadows, mid-tones and highlights to match the two traces as closely as possible. You can also use Curves controls. Adjust the color channels separately. When adjusting shadow controls, look at the bottom portion of the waveform monitor. When doing highlights, keep an eye on the top of the trace. When the general shapes of the waveforms match across all three channels, the images should be very well matched (Figure 5-14).

You can compare the final color corrected match of the two shots in Figure 5-15 and Figure 5-16.

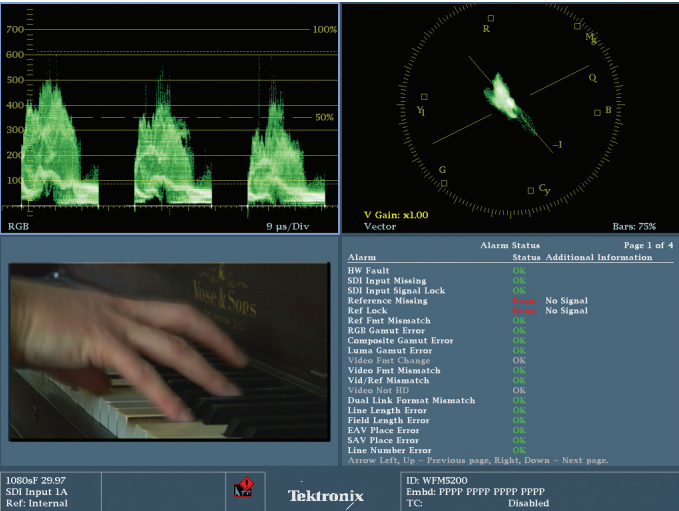


Figure 5-15. This is the final “hero” match showing four quadrants of information in the WFM5200.

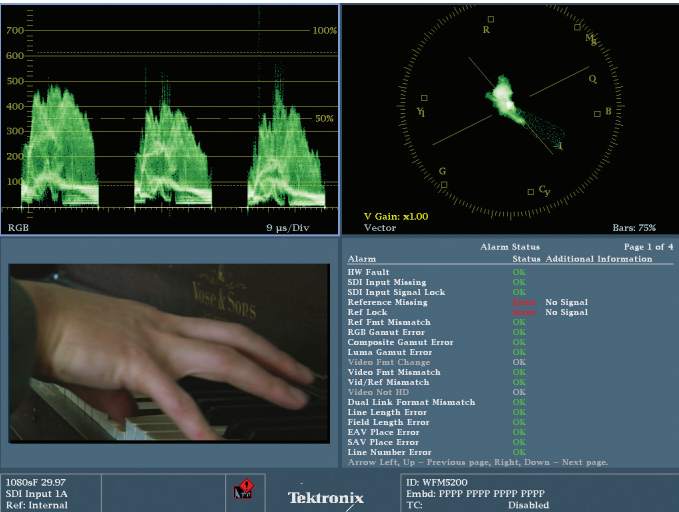


Figure 5-16. This is the “matched” shot showing four quadrants of information in the WFM5200.



Figure 5-17. This is the uncorrected “hero” shot or main camera.

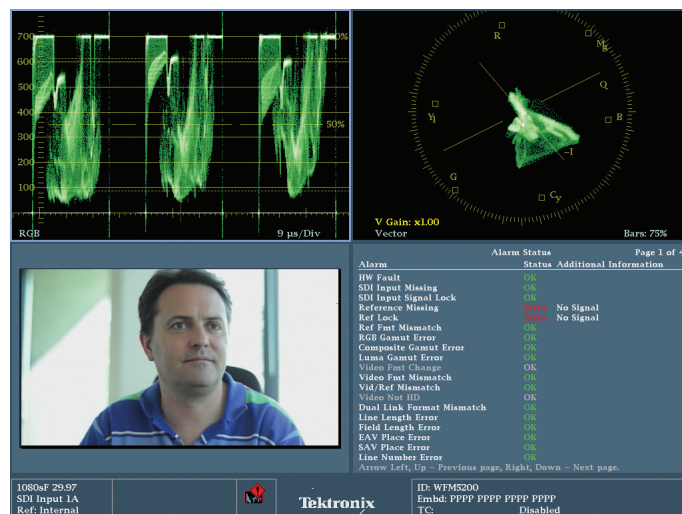


Figure 5-18. This is the uncorrected shot we will match to the “hero” grade. This shot is cooler than our “hero” shot.

Oftentimes, the colorist needs to match cameras shot from two different positions. With two different camera positions, they also have two different views of the subject, so the waveforms won't match up as well as in the previous example or in the example with the grayscale chart.

With two different waveforms, the goal is to identify sections of the trace that should be the same in both cameras. This can be the levels and balance of a flesh tone, or a specific color in an article of wardrobe or portion of the foreground or background, like a wall or table.

In Section 4 of this Primer, there were numerous examples presented to show the relationship between a portion of an image and a portion of the trace on the waveform that represents the image. Finding portions of the image and trace that correspond will be very important in handling this type of match.

The primary items that we'll be able to match will be the black of the chair that the subject is sitting in, the flesh tones of the subject and the color of the wall that's behind the subject's head (Figure 5-17). The windows behind the subject are clipped, as can be seen by the bright, tight line of trace along the top of the waveform. Because of this clipping, you can't rely on the specific relationships between the color channels, because they could be distorted.



Figure 5-19. Four tile display with Tektronix Diamond display of uncorrected image.

The easiest thing to identify and match is the black levels and the clipped white levels. Before trying to match the cameras, we'll first get the camera that's closest to the look we want into better shape.



Figure 5-20. Our main camera with the “hero” grade. Note that the CURSOR was turned on and adjusted to better judge the relative color channel levels of the part of the trace indicating the gray wall behind the subject’s head.

The primary shot is very close, but the blacks are a little lifted. We’ll adjust the black levels to bring the levels down to 0. Then the Master Gain to bring the clipped highlights back to 100%. With those levels set, adjust the mid-tones to a pleasing visual level. To richen the shot and provide some contrast to the bright highlights, the mid-tones were lowered slightly. When mid-tones are lowered, this often causes an increase in saturation. Some color grading systems are able to compensate for this, but most do not. Also, the CURSOR function was turned on by pressing the CURSOR button and adjusted with the General dial to have a better reference to the levels and balance between the red, green and blue channels.

Note that there is a fairly definitive angled line in the trace at about 500mv, right where the CURSOR was placed in Figure 5-20 (immediately above). The position of this line is equal in all three color channels. This line represents the gray wall extending from the right side of the subject’s head all the way to the edge of the frame. Directly below this line at the bottom of the trace is a line near the bottom of the waveform monitor that represents the back of the black chair that the subject is sitting in. Also, note that between the black of the chair and the white of the wall there is a lot of fine trace in the blue channel, but not so much in the green and red channels. This is the blue shirt color. Also note that there is fine trace above the line that designates the gray wall in the blue and green channels, but not the red channel. This is also color from the shirt, specifically the bright green at the top of the left shoulder. Of course, the

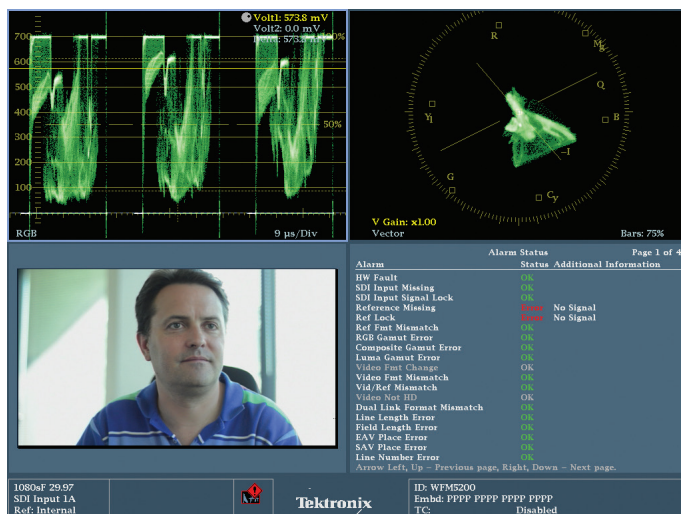


Figure 5-21. This is the uncorrected second camera that will be matched to the “hero” shot.

bright line of trace along the top of the screen indicates the bokeh in the blown out windows. (Bokeh is the term for blurry, out of focus points of light). Finally, and most importantly, the flesh tone of the subject is indicated by a checkmark or “V” shape in the middle of the trace, directly below an area where the trace seems empty. This empty space is where the subject’s head blocks the bright window and then transitions to the wall on the other side. Note that the strength of the color channels in this area of the trace is weighted more heavily to red, with blue being the weakest channel by a little. This is the typical ratio of color channels when indicating a flesh tone. The bottom of the skin tone “V” is just a little above 200mv in the red channel, a little below 200mv in the green channel, and slightly lower than that in the blue channel.

Now let’s compare these same features in the shot we want to match (Figure 5-21).

Note that the black levels are quite elevated. The lowest level is about 50mv. The clipped whites are at 100%. Note that the gray wall in this shot is on the other side of the subject’s head because of the camera position. The wall is visible as a sharp, short line at about 550 mv in the red channel, just above 600 mv in the green channel and just below 600 mv in the blue channel. These levels in our “master shot” were all equal. Also, note that the yellow cursor line is at the same place as it was in our “hero” grade, but the trace indicating the wall is below it in the red channel and above it in the blue and green channels. Finally, note the checkmark or “V” shape of the skin tones. The bottom of the “V” is at about 300 mv in the red channel and at about 200 mv in the blue and green channels.

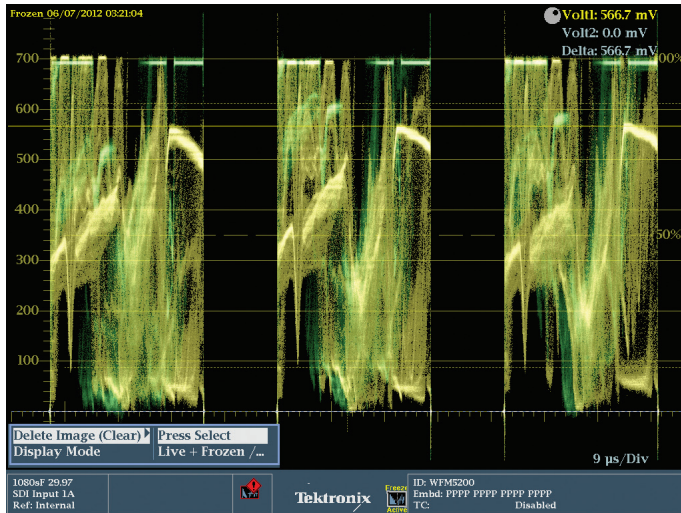


Figure 5-22. The “hero” grade is displayed in gold trace. The 2nd camera has had only the blacks set and is indicated in green. The green trace is the “live” trace and will move as adjustments are made.

To make our match, we start out by lowering our black levels using a black, setup or lift control to bring them down to 0. With the blacks closer to 0, the blue channel still seems elevated, which makes sense because the entire image seems to be slightly blue. Use a shadow adjustment in the blue channel to bring the blue channel down to match the red and green channel, creating a rich, balanced black. Then we’ll return the white, clipped highlights to their original position at 700 mv.

With the overall levels of the two shots matching closer, we will switch the timeline back to the “master shot” and use the CAPTURE button again to freeze the trace. Then switch the timeline back so that the cooler shot is feeding the green trace of the waveform monitor (Figure 5-22).

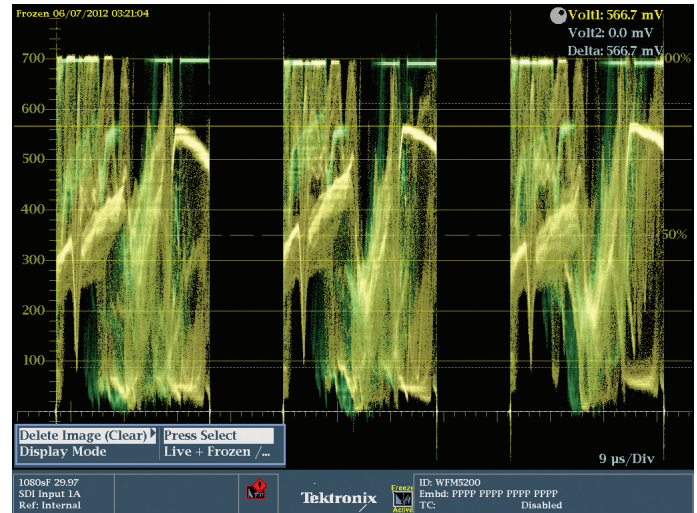


Figure 5-23. Using the Capture button it is easier to see the matching waveforms. The relative levels of all of the color channels are matching.

With the two traces laid over each other, there are two areas that can be seen that are “off.” First, note the position in the two traces of the portion of the wall that’s visible. In our “master” shot, for that section of the trace, all three channels are the same strength at about 550 mv. As described in the previous paragraph, the levels of that part of the trace in the shot we want to match are at three slightly different levels on either side of 550 mv.

Use a gamma or mid-tone control in the red, green and blue channels to match these points in the green trace with the same points in the gold trace. With the levels in each channel matching for the “V” of flesh tone and for the line indicating the gray wall, adjust the master saturation level of the second shot to match the “master shot.”

You can compare the final color corrected images in Figure 5-24 and Figure 5-25.



Figure 5-24. The finished main camera shot.

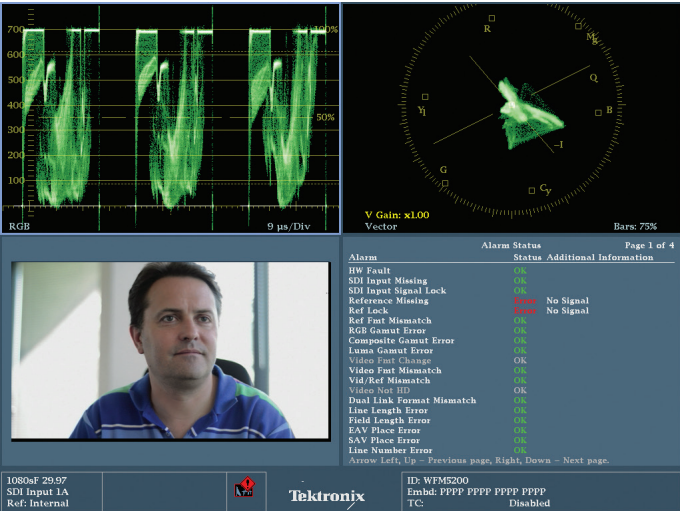
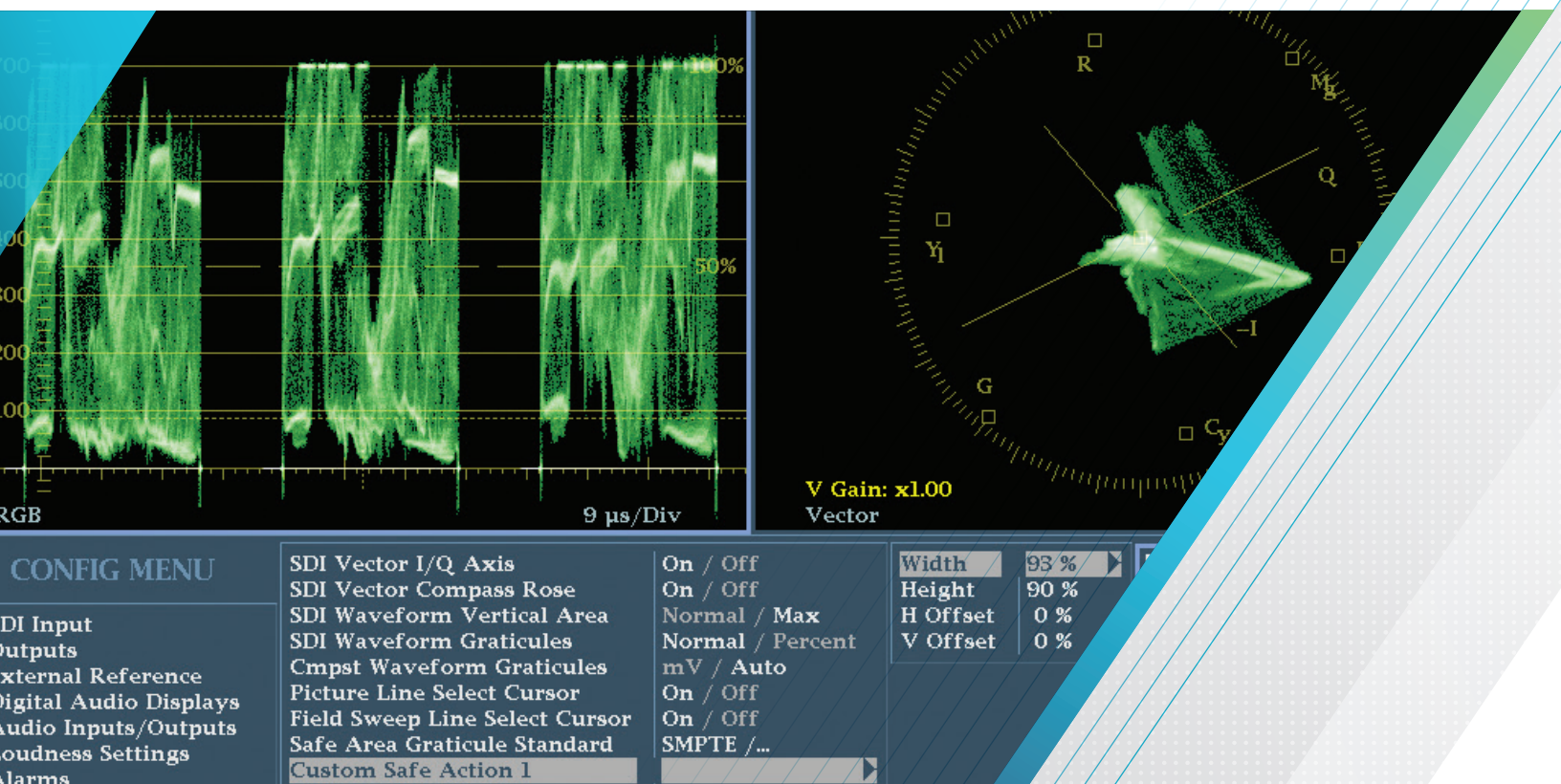


Figure 5-25. The finished second camera shot.

To learn more, watch this short [“How-To” Guide on Color Correction for Video - Scene Matching.](#)

Section 6:

Editing for Compliance to Broadcast Specifications



Section 6 Editing for Compliance to Broadcast Specifications

Throughout this primer, we've discussed the importance of maintaining legal and valid levels and meeting broadcast specifications. In this section we'll discuss three additional specific ways to use Tektronix waveform monitors to stay in compliance with broadcast regulations.

1. How to use secondaries to maintain the look you want while still being legal
2. How to understand delivery documents from broadcasters and set up alarms for automatic content QC.
3. How to measure SPACE with a waveform monitor

USING SECONDARIES TO FIX GAMUT ISSUES

Using “secondaries” to solve gamut issues is one of the powerful tools in the colorist's toolbox for maintaining compliance without sacrificing the image. In color correction applications, a secondary is a reference to a color correction that only affects a specific portion - or “vector” - of the picture.

This ability of a secondary color correction to isolate a specific vector or color makes it ideal for dealing with many gamut issues because gamut issues often occur due to a single highly saturated light or piece of clothing. Instead of simply lowering overall saturation or gain until the gamut violation disappears, use a secondary color correction to isolate or “qualify” that specific color and just bring that single color into compliance, leaving the rest of the image vibrant and interesting. It's easy

to see these colors come back into compliance as you adjust your secondary color correction.

Executing a secondary color correction is a two step process. The first step is to isolate, select or “qualify” the portion of the picture that you want the color correction to apply to. Sometimes this is done using a “window” or “vignette” which defines an area of the picture using a shape mask. In our case, the “qualification” is done by selecting the specific color - or vector - of the image that we want to alter. Because each color correction application does this in slightly different ways, the directions will not be step-by-step, but more general in nature.

First, with an image with a gamut violation from a strong color called up in your color correction application, find the secondary color correction tools in the application. In Avid, there is a tab in color correction mode called “Secondaries.”

Usually, these applications will select the color that is in violation using an eyedropper tool or syringe tool. There should also be Hue, Saturation and Luma (HSL) sliders that allow you to revise or edit this eyedropper selection, either making it more inclusive or more exclusive. Adjust the HSL sliders to properly select all of the offending color. You may also need to play with the “softness” of the selection.

With the selection made, you can simply lower the saturation or brightness of the out-of-gamut color. This will bring that particular vector (specific color) into compliance without changing the rest of the image.

AUTOMATIC ALARMS AND QC

Although it is the colorist's job to walk through the shots one by one, setting a look and checking for technical level issues, there are also times when having some automated QC (quality control) help is valuable. Tektronix waveform monitors, like the WFM5200, are capable of monitoring the signal and generating reports providing the specific timecodes of any violations. These violations can then be looked at and dealt with on a case by case basis.

The first step of this process is to find and read the video delivery document for the broadcaster whose network will present the video. Many broadcaster have similar specifications for delivery, but each broadcaster has unique requirements for signal levels and other technical specifications.

Here are some relevant paragraphs from PBS's spec sheet.

2.2 PBS VIDEO LEVELS AND GAMUT

2.2.1 Conversion between Y', Cb' Cr' to GBR colorspace can create invalid colors and thus gamut errors. Out of gamut errors generally arise when video computer graphical sequences are authored in Y, Cb, Cr. A waveform monitor which clearly defines gamut limits for HD video should be used to ensure that all video elements within the submission do not generate any out of gamut errors.

2.2.1.1 Objectionable black clipping must not be evident. The black level must be set to 0v on the Y' waveform. Black setup is not allowed in any digital submissions.

2.2.1.2 Peak Y', Cb', Cr' video amplitude each must be no more than 0.7v peak to peak. Since certain combinations Y', Cb', Cr' will create out of gamut colors; close attention should be paid to gamut indicators.

2.2.2 Producers should be aware that the GBR gamut will be hard limited ("legalized") to the 0 to 700 millivolt range when the final PBS package is created for distribution.

Basically all four of these paragraphs are saying that the lowest level is 0mv and the highest is .7v or 700mv.

In order to properly monitor the signal to adhere to these specifications, the operator must check that these are the warning levels for the waveform monitor. Sometimes, default levels can be set so that there is some degree of latitude or "slop." These PBS requirements provide firm guidelines, so setting the preferences for gamut violations to adhere strictly to these guidelines will insure that there are no QC issues with the production when it goes through PBS's QC process. Additionally the legalizer will clip the image to these limits and possibly destroy the intended look. Therefore it is better to ensure that your material meets these limits rather than having a device clip your image to the specified limits.

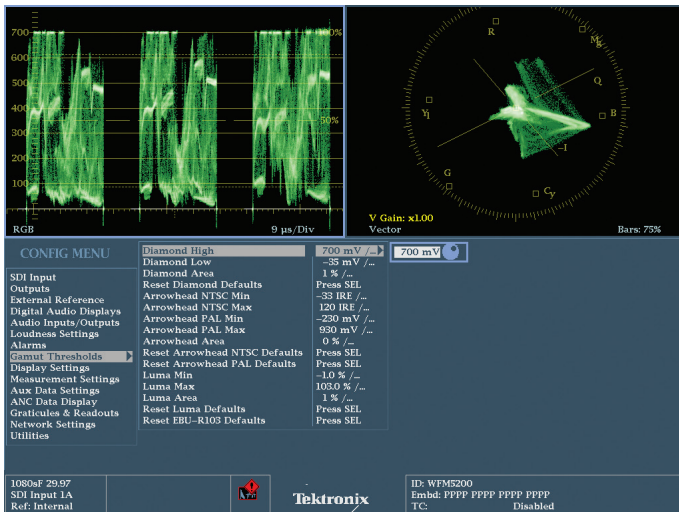


Figure 7-1. The Config menu is recalled by pressing the CONFIG button. Navigate through the choices with the arrow menus and General dial.

To insure compliance, there are a number of settings and dialogs to check and reset if necessary.

The main location for these settings is in the Gamut Thresholds sub-menu of the CONFIG menu (Figure 7-1). To set these thresholds, follow the following steps:

1. Press the CONFIG button on the WFM or WVR5200. This calls up the CONFIG menu. There are selections such as SDI Input, External Reference, Digital Audio Displays, etc.
2. Use the General knob or the up and down arrow keys to scroll through the list and select the Gamut Thresholds option.

3. Press the right arrow to move into the menu choices to the right: Diamond High, Diamond Low, etc.
4. Use the General knob or the up and down arrow keys to move through this menu. Stop on any menu choice that needs to be revised according to the broadcaster requirements document.
5. Use the right arrow to move over to the numerical value. A numeric value and a dial icon will appear. Use the General knob to change the numeric value to the correct value. For example, the PBS document says that no signal in any channel can exceed 700mv. The preset value is 735mv.
6. When the numeric value is set, use the left arrow to move back to the threshold list and the General dial or up and down arrows to select another option. Follow step 5 again to change the new parameter.
7. When all Gamut Thresholds have been changed, press the CONFIG button again to save your changes.

Now that you have set these thresholds, the various alarms will use these thresholds instead of the defaults. It may be possible with some broadcasters to get the actual settings that they use for QC, but they should be the same as the standards document.

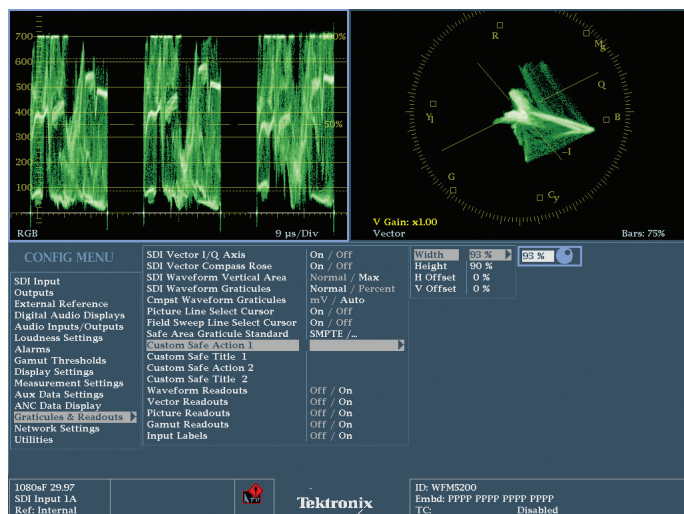


Figure 7-2. The CONFIG menu has a menu option for changing Safe Title and Safe Action.

MEASURING SPACE ON THE WAVEFORM MONITOR

The PBS document also gives standards for the safe action and safe title areas based on percentage of the entire raster. This is also how the Tektronix waveform monitor measures safe action and safe title, so you can use their recommendations for setting the safe action and safe title on your Tektronix display.

From PBS:

2.3.4.1 Safe Action is the area within which all signification action must be contained. The area is 93% of the width and height of the production aperture.

2.3.4.2 Safe Title Area is the area within which all significant text must be contained. The area is 90% of the width and height of the production aperture.

You can set these same standards for your Tektronix waveform monitor (Figure 7-2):

1. Press the CONFIG button on the WFM5200 or WVR5200.
2. Use the General knob or up and down arrows to navigate to the Graticules and Readouts option.
3. Press the right arrow to move to the selections: SDI Vector I/Q axis, SDI Vector Compass box, etc.
4. Use the General knob or up and down arrows to navigate to the Custom Save Action 1 option.
5. Press the right arrow twice to get to the numeric selection for Width.
6. Use the General knob or up and down arrows to change the Safe Action from the default of 90% to PBS's recommendation of 93%.
7. Press the left arrow and the down arrow to move down to the numeric selection for Height and change that to 90% as well.
8. Press the left arrow twice to move back to the Custom Safe Title option and follow steps 5, 6 and 7 to change the Safe Title Width and Height selections from the default to 90%.

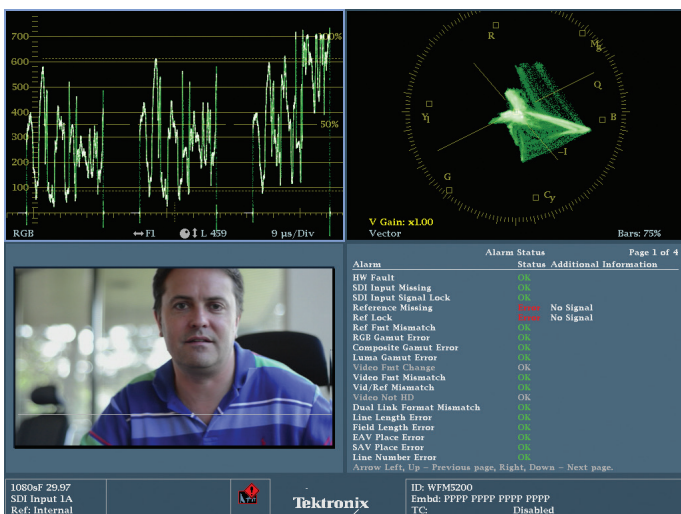


Figure 7-3. Note the thin white line that extends across the width of the Picture monitor across the shirt at the collar level. This is a visual indication of what line is selected. Then, at the bottom of the quadrant with the waveform monitor, note the icon for the General dial and the number 459. That indicates numerically which line you have selected.

For many companies, Safe Title and Safe action are the only “space” or “location” settings you’ll need to know, but sometimes networks will also stipulate that you can’t violate a specific area of the screen that is INSIDE of Safe Title or Safe Action. Usually this involves the placement of the network’s BUG or the little network ID that usually sits in the lower right corner of the screen. Let’s take a look at this example from The Discovery Channel: “No text shall fall into the space between 38.7 microseconds and 50.0 microseconds between lines 190 and 243 (field 1) NTSC.”

The first thing we need to do is to understand where lines 459 and 541 are vertically on the monitor.

1. Call up a preset that has both a picture monitor and a standard waveform monitor.
2. Use the LINE SEL button on the face of the WFM5200 or other Tektronix waveform monitor or rasterizer (Figure 7-3). This causes the waveform monitor (or any trace display) to only “read” a single horizontal line of video. Look at the Picture monitor and use the General dial at the top right. Adjust the dial and you will see a white horizontal line on the Picture monitor.
3. Continue to adjust the General dial as you watch the horizontal line. Also, look at the bottom of the waveform display and you will see a dial icon and a numeric reading. If you are monitoring a field-based (interlaced) video signal you will need to pay attention to the numeric figures for both fields. Even though there are 1080 lines of video, these are divided into two fields, so the bottom of the first field is not 1080, but HALF of 1080, which is 540. So the bottom of the display is essentially line 541.
4. While watching the numeric display at the bottom of the waveform monitor set for a progressive video signal, move the General dial to move the white line until the numeric display reads 459. This is approximately 80 lines above the bottom of the screen. The interlaced line number (459) is the first number on the display and the second number, for progressive lines, is indicated inside the parentheses (1022).
5. If you want, with your live source, use something like a wipe in your NLE to translate the location from the Waveform Monitor to the edit system. In other words, line up the 459 line on the waveform monitor with a horizontal wipe coming from your edit system. Now you know where line 459 is in your edit system.
6. This gives you the two positions in vertical space between which no text can fall in order to avoid the broadcaster’s bug.

As you will see, this is a common area where lower third graphics often are positioned. But, the broadcaster’s spec will allow text between those lines as long as they ALSO aren’t between 21 and 24.5 microseconds. But how do microseconds translate into a horizontal position on the waveform monitor?

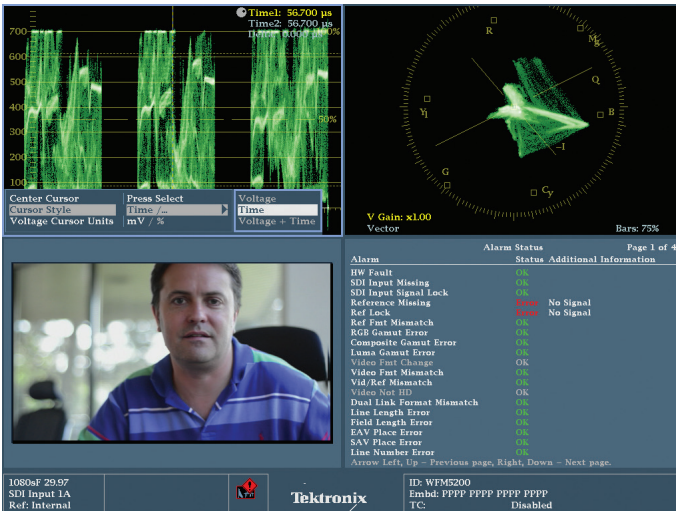


Figure 7-4. Holding down the CURSOR button calls up the Cursor menu. Switching the Cursor Style to Time changes the Cursor to a vertical orientation and allows you to measure in milliseconds.

For the horizontal placement of the bug:

1. Looking at a waveform monitor, hold down the CURSOR button to call up the CURSOR menu. Under Cursor style, select "time." That will become a cursor that runs vertically. (Choosing "voltage" gets you a horizontal cursor.)
2. You can move the cursor with the General dial in the top right corner and dial in to the prescribed number of milliseconds (Figure 7-4).
3. Again, manipulate something in your video feed – like a live wipe in Avid or Final Cut Pro – and you can find the area for the bug.

Another broadcast specification, often in advertising, is how small disclaimer type can be. Because font size in various fonts and various applications can vary, broadcasters do not specify a font size, but instead specify the number of vertical lines that must be in the finished video. An example would be 9 lines tall for a capital letter, or 12 lines tall for a lower-case "n."

To measure this:

1. Type several lines of varying heights in Photoshop or your NLE's Title Tool using the specific font you or the art director want to use. As part of each line of type, include the font size that you used to type the line. If you used the built in title tool of an NLE, send the title out to video so it is displayed on the WFM 5200. If you did it in Photoshop, export from Photoshop, import into your NLE and cut the graphic in to your timeline so it displays on the WFM 5200.

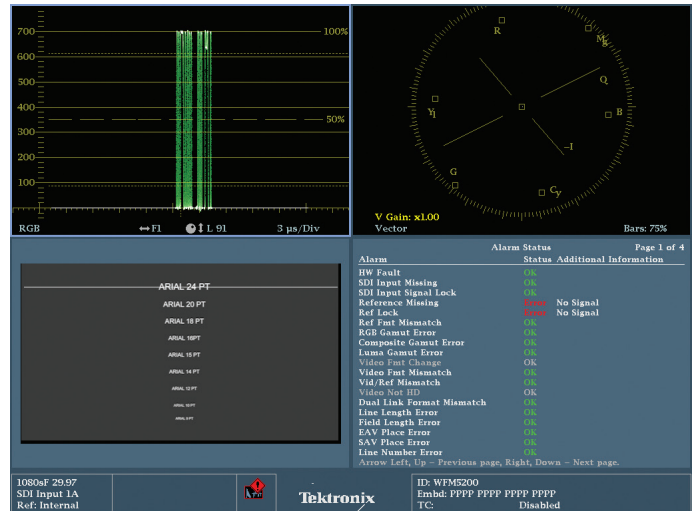


Figure 7-5. The LINE SELECT option is on. The waveform trace shows a signal from 0 - 100%, indicating that the line is placed over white text. This can be confirmed by looking at the position of the line across the top row of text. Although the text generator said that the font was 24 pixels high, the waveform shows that the text only extends from line 81 to line 101 - or 20 lines tall.

2. Use LINE SELECT to see the horizontal cursor. Manipulate the General dial to position the cursor just above or just below one of the lines of text on the screen (Figure 7-5).
3. As you use the General dial to roll the Line Select up and down, the trace will show where the white letters are. When the line is over black background only, the waveform should rest at 0mv. When the Line Select is positioned on a video line with white text, the waveform will jump up to approximately 100.
4. Count the values of the Line Select's numerical display to determine the height of the lines of text.
5. When you find one of your lines of text that has text that is nine lines (or whatever the specification from the broadcaster is), note the font size of that line.
6. Go back to Photoshop or the NLE's title tool and use that font size in the same font and you will be within broadcast spec.
7. To be safe, use the same procedures to check that the final disclaimer text is within spec.

To learn more, click on this link to watch this short "How-To" Guide on Color Correction for Video – [Editing for Compliance to Broadcast Specifications](#).

Section 7:

Choosing your Waveform Monitor for Color Grading



Section 7 Choosing your Waveform Monitor for Color Grading

WHY DO YOU NEED WAVEFORM MONITORS & RASTERIZERS ("SCOPES")

For some people unfamiliar with using a waveform monitor to do color grading, the question of which waveform monitor to use may be a question of "Why use a waveform monitor?" Waveform monitors are essential in the same way that audio monitors or VU meters are essential. Without audio meters, each audio edit may sound okay next to the one beside it, but over the course of a program, the levels could easily slip a substantial amount as you progress farther and farther from your initial point of reference. Or imagine completing a mix without audio meters, only to discover that the monitors were turned up very loud, making your mix much too low. Similarly, if you are hearing distortion in the audio, the first thing you do is check your meters to see if the distortion is in the original source material, or whether it occurred due to some processing in the edit or maybe is happening because of the way an external audio board or your speakers themselves are set.

Waveform monitors are needed for similar reasons. They are the single trusted baseline for your video. Your eyes can be fooled when trying to judge color temperature or levels over the course of a day, and it's possible to have accidental changes occur due to the set-up of a computer monitor or a video monitor's levels which could cause a program to be incorrectly color corrected. In these instances, the waveform monitor provides the "truth" of the signal, assuring you that the technical and creative decisions that you spend so much effort to create are based on a trusted source that is the same throughout the world.

While some very high end colorists are able to do some initial color grading without scopes, they are aided by years and years of experience and by a video monitor that is perfectly calibrated and that they know they can rely on. However, colorists with less experience, and without a reference video monitor that costs more than most waveform monitors, need to use scopes to best analyze the signal and know what needs to be done and how far it's possible to push the signal.

INTERNAL OR EXTERNAL SCOPES

For a colorist in a small boutique or with limited resources, it may be tempting to use the built in scopes available inside your color grading application or NLE. While these internal scopes are a reasonable facsimile of a real waveform monitor, there are a number of arguments against using them for serious work.

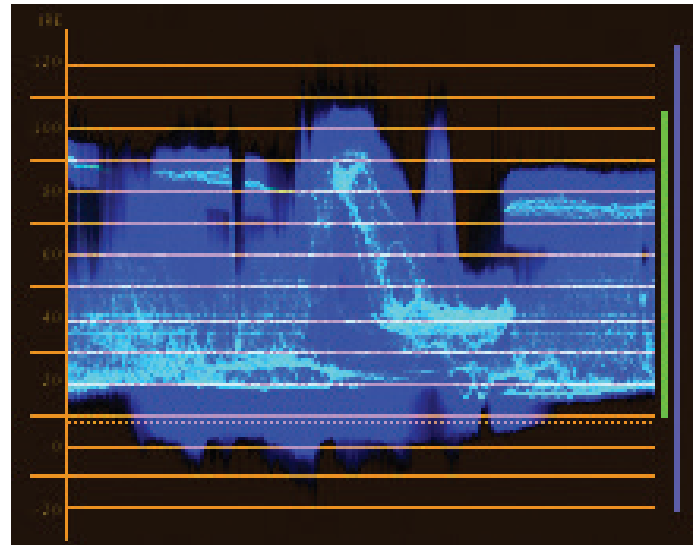


Figure 8-1. This is the internal waveform monitor of one of the major NLEs.

Resolution

A primary distinguishing factor between quality scopes is the resolution of the trace. As has been discussed in previous sections of this Primer, the trace is the waveform display representing the video signal levels on the waveform monitor. Internal scopes, like those built-in to your favorite NLE or color grading application, generally have a very poor resolution because the greater the resolution, the more computer horsepower needs to be assigned to the waveform monitors, pulling functionality and responsiveness away from the true purpose of your application. The developers of these applications are much more concerned with your user experience in the user interface and the application's ability to deliver a good user experience, so they don't want to use precious computer cycles on processing the waveform display. With an external waveform monitor, its sole purpose is to perform as a waveform monitor, so the total processing power built into the unit is accessed to create the display, resulting in a higher resolution. Sometimes, very small specular highlights or other transient portions of the signal are missed on lower end scopes.

This lowered resolution can be the result of several things. For example, the software scopes internal to editing and color grading applications may not present information on all of the lines of the video raster. They appear to give you all of the lines but are in fact only presenting a quarter or a 16th of the number of possible lines, similar to viewing a scene through a set of half-closed venetian blinds. This is very dangerous for trying to establish broadcast limits because you could have illegal areas — like a bright specular point — that sneaks in between the lines that are being analyzed by the scope.

Refresh Rate

Another issue with some scopes is the frequency with which the data in the waveform monitor is updated. One well-known editing application only updates the trace information in the waveform monitor AFTER color grading has been applied! So as you're trying to adjust a parameter, you have to continually "release" your grading to see what effect the grading has had. This makes the internal scopes virtually worthless because of the amount of time that has to be added to the color grading process. Other scopes may seem to be updating the waveform trace, but may in fact only refresh the scope display a few times per second, missing important video signal changes that happen for a short time, like a specular highlight on a passing car.

Customization

The other key area where Tektronix scopes outperform internal scopes is their ability to be customized. Often times, internal scopes have no ability to zoom in, add gain, reposition, or even alter the brightness of the trace. These features are important in properly analyzing the issue. In Section 8 of this Primer, Tektronix presets are discussed in detail. These presets allow you to quickly customize and recall settings and groupings of important tools and displays so that you are able to color correct efficiently and easily saving valuable time. Most internal scopes have no ability to change their appearance or settings at all, and the ones that they do are usually very limited and have to be operated by time-consuming menus and on-screen button clicks.

Legal Levels

In addition to providing a creative eye and execution of a creative vision, the colorist is also the one tasked with delivering a technically correct video signal that will pass quality control and will look the same down the delivery path as it does on the client monitor during the grading session. The colorist must insure that luma and chroma signals are within certain technical limits. All of the creative effort of the production can be ruined if the footage is "illegal" and the broadcaster or distributor refuses to accept the project because of technical problems, that will then require the material to be reworked. Legal limits are set by broadcasters and cable operators and vary from one to the next. But even if your product isn't being broadcast, legal levels affect the proper duplication of your project and the way it will look on a regular TV monitor. Some people believe they can rely on downstream video limiters or legalizers. These devices definitely work, but if you are delivering an illegal signal to the legalizer, then your final product will not look like it did on the monitor when you were correcting it. The clipping of luma signals and gamut limitations that the legalizer imposes on the signal can drastically alter the look of colors and levels and altering the look of the program. As with most things, hand-crafting the look will result in a much better result than leaving your final color grading to a legalizer.

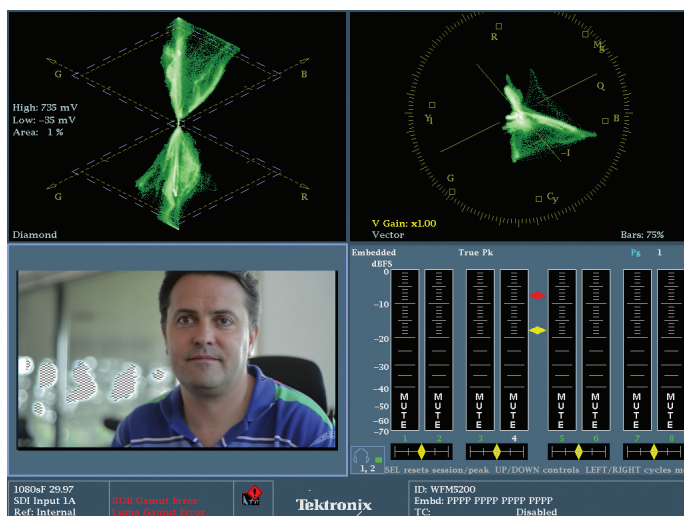


Figure 8-2. Tektronix patented Diamond display.

Patented Displays

Section 2 of this Primer discusses the patented Diamond (Figure 8-2) and Spearhead displays. There are also discussions throughout this primer of other patented Tektronix displays, such as Luma Qualified Vectorscope and Arrowhead displays. These specific displays are not available on any other external scope or internal scopes. They provide critical information that is not available anywhere else.



Figure 8-3. Error logging with time code.

Automatic Timecode Logging of Errors

Another benefit in Tektronix waveform monitors that is unavailable inside of NLEs and color grading applications is the ability to monitor an entire program and log errors automatically (Figure 8-3). This ability frees the colorist to make creative choices, and to know that technical issues that are missed in an initial pass can be discovered and corrected by checking the log and going back to hand-correct the illegal levels discovered by the waveform monitor. Additionally, as we discuss elsewhere in this document, the settings and tolerances of those error logs can be fully customized so that the broadcast requirements of a specific broadcaster can be monitored and met.

Once your master has been completed you can play the material through the instrument to provide a final Quality Check (QC). Any errors that are found are shown within the Error Log, if timecode is present within the material then these error can be related to timecode allowing the user to go back to specific parts of the material and make any corrections necessary. For gamut errors a Uppercase letter indicates that the upper gamut limits have been exceeded and a lower case letter indicates that the lower threshold has been exceeded.

Downstream of The Video Card

Another issue with internal scopes is that they are simply a facsimile of what the computer thinks the output will be, but there is no way to account for downstream settings on the video card or any other issues that can occur downstream of the video card itself. The internal scopes may not match the final output to tape or to your rendered file at all.

A new breed of waveform monitor uses software and a video card from a spare computer to create a waveform. While these scopes address the problem of seeing the signal downstream of the video card, they are generally not customizable at all and deliver a preset display that can't be adjusted by the operator and are still dependent on the processing speed of the computer.

CHOOSING WHICH TEKTRONIX PRODUCT IS RIGHT FOR YOU

Once the decision is made that you need an external waveform monitor and that Tektronix is the brand that provides the tools that you need to get the job done, you have a choice of several different models to choose from.

For a colorist, the choices between the models really comes down to two questions:

1. Do I need to see four trace displays at once, or will two be enough?
2. Do I need a waveform monitor with a built-in display?

The 7000, 8000 and 5000 series waveform monitors have numerous feature differences, but for the colorist, the main differentiator between these models is that the 7000 and 8000 series are capable of displaying four different “trace” displays at once. The trace displays are waveform monitors, parade waveform monitors, vectorscopes, and gamut displays. Non-trace displays are things like picture monitors, audio monitors and status displays. Many colorists, especially seasoned colorists, prefer to be able to monitor as many as four different trace displays at once. Just a few years ago, the only way to do this was to purchase four different waveform monitors and line them up across the console in front of the colorist. This was very expensive and used a lot of the real estate of the colorist's desk. Now the 7000 and 8000 series can display four traces at once.



Figure 8-4. The Tektronix WVR 5200 Compact Rasterizer and WFM 5200 Compact Waveform Monitor.

The 5000 series can only display two trace displays at a time. The WVR5200 and WFM5200 are significantly less expensive than the 7000 and 8000 series, but if you need four trace displays, this will be the determining factor between them.

The difference between the 7000 and 8000 models is primarily based on features for broadcast and video engineers. Unless the waveform monitor needs to also be used by a broadcast or video engineer, the 7000 series model will be the most economical choice for the colorist suite.

The other question of needing a built-in display determines whether the WVR or WFM models are the appropriate choice for you. The WVR models are less expensive than the WFM models because the WVR models are “rasterizers.” The WVR designation comes from the “r” in “rasterizer.” These models do not have a built in display. They must use an external DVI-D or VGA capable computer monitor to display the waveform. The WVR is a small rack mounted unit consisting solely of the same buttons and dials that are on the front of the WFM models. For most colorists, this is probably a preferable

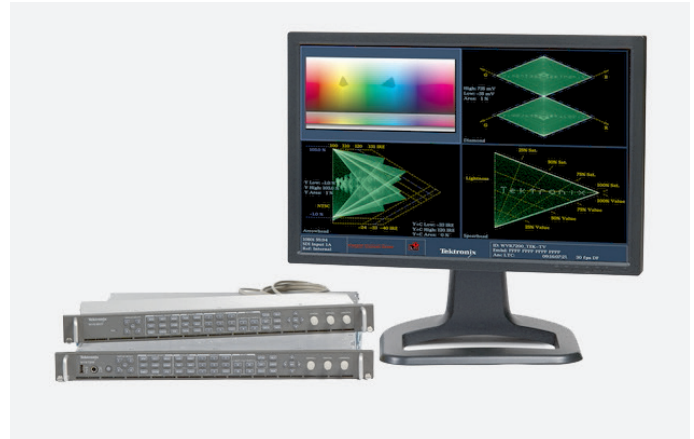


Figure 8-5. The Tektronix WVR7200 Multi-format, Multi-standard SD/HD/3D Rasterizer.

choice. The WVR is smaller than the WFM and since the colorist probably wants to see a larger image of the waveform monitor, and because the WVR can actually run into a secondary input for one of the colorist’s existing monitors, the extra expense of the WFM is unnecessary.

The “on-board” monitoring capability of the WFM model is useful if the waveform monitor is going to be placed in a rack or truck with limited space for an extra computer monitor. It can also be useful in a smaller production house if the monitor will be occasionally pulled from the colorist’s suite to do double-duty as a field monitor on shoots.

For most colorists, the most economical choice will be the WVR5200 to deliver two trace displays or the WVR7000 to deliver four trace displays.

Click on this link to watch a [A Guide to Using Waveform Monitors and Rasterizers for Color Grading](#).

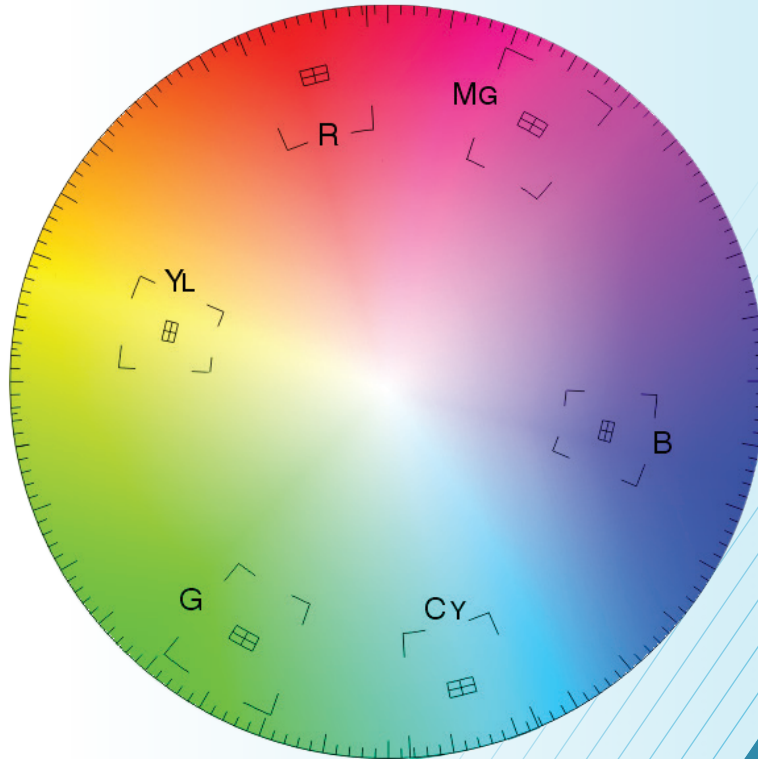
CONCLUSION

This primer has guided you through the process of using a waveform monitor to ensure the quality of your material and ensure it is within broadcast limits. The waveform monitor provides a reference to your video levels so that you can gauge the headroom you have to make adjustment while keeping the signal legal. Traditionally waveform display such as RGB Parade and vector displays have been used to monitor the video levels of the signal. Tektronix has developed specific display such as Diamond, Spearhead and Luma Qualified Vector to assist colorists and editors in making adjustments to the signal and keeping within specific gamut limits, allowing the users to quickly identify the component in error and make adjustment to their system. By the use of custom preset the user can quickly configure the instrument in a variety of different ways to suit their needs and workflow allow you to focus on the creative process and save time. Once the final master is produced the waveform monitor can be used to QC the material and identify any possible errors before the material is sent to the customer. This can save time and cost rework of the material.

For nearly all professional colorists, the various waveform displays — Flat Pass, Luma only, RGB Parade, and YCbCr Parade — plus the vectorscope are the main methods for analyzing your image. Tektronix has added to this list with Diamond, Spearhead and Luma Qualified Vector. While experienced colorists often rely on their eyes, they use these scopes to provide an unchanging reference to guide them as they spend hours color correcting. Without them, their eyes and grades would eventually drift off course. Spend time becoming comfortable with these scopes and knowing what part of the video image corresponds to the images on the scopes.

Section 8:

Glossary of terms for Color Grading



Section 8 Glossary of terms for Color Grading

10-bit The number of levels available in a digital video signal. 10-bit offers 1023 levels, four times the accuracy of 8-bit, and vastly superior for telecine transfers and chroma-keying.

4:2:2 The sampling ratio used in the D1 (CCIR 601) digital component video signal. For every 4 samples of luminance there are 2 samples each of R-Y (Red minus Luma) and B-Y (Blue minus luma). Thus it has full black and white resolution, but only half the color information. The best digital standard in the early 1990's.

4:4:4 A sampling ratio that has equal amounts of the luma and both chrominance channels. The new digital component video standard that has full color information as well as full black and white information. 4:4:4 provides better color resolution than ever before, improves telecine transfers and chroma-keying.

8-bit The number of levels available in an older digital video signals. 8-bit offers 255 levels. D1 and Digi-Beta are 8 bit

Additive Color Color mixture by the addition of light of the three primaries, red, green, and blue.

Artifact The usually unwanted, visible effect caused by a technical limitation of a process or system.

Black Crushing Loss of low light (shadow) detail caused by adjusting luminance information below the Black Level.

Black Level Signal Level corresponding to minimum light output, (the shadow area).

Bleach Bypass/Reduction A cross processed film look resulting from a reduced or skipped bleach bath during color film processing. Some of the silver image remains and less of the color dye is coupled creating a distinctive contrasty faded look.

Bokeh Blurry, out of focus points of light

Burn Out 1) A loss of information in highlights usually as a result of a system clip or limit. 2) Instruction to a colorist to increase gain levels so much that the lighter parts of the image become white, and highlight detail is lost.

Chrominance (also known as chroma) 1) The color part of a video signal. 2) The property of light which produces a sensation of color in the human eye, apart from any variation of luminance which may be present.

Color Gamut In a system employing three color primaries to encode image color, each primary can be located on a CIE chromaticity diagram and these points connected as a plane figure. If the apexes are then connected with an appropriate value on the white point axis, a solid figure is produced enclosing the color gamut for that system. (On the CIE chromaticity diagrams, the points in x, y, z space approximates an inverted tetrahedron. In u, v, w space, they become a somewhat irregular four-cornered solid.) Colors within the color gamut solid volume can be reproduced by the system as metameric matches. Colors outside the color gamut solid volume cannot be matched. Note: The area of the cross-section from the color gamut solid is a function of the lumai. Although it is advantageous to have the widest possible color gamut for the ability to provide metameric matches for the largest number of colors, the required transformations from origination colorimetry to colorimetry matched to available display primaries, for example, may require large matrix coefficients and, therefore, a signal-to-noise penalty. The choice of color gamut is a compromise between color rendition and signal-to-noise.

Clipping Electronic limits imposed to prevent signals exceeding maximum levels for white, black and chrominance. Hard clips simply remove all data at a define level. Soft clips attempt to retain some data by compressing the signal. See also Legal Color Limiting.

Color Balance The removal of color casts from an image. Also the removal of color casts from a camera or monitor.

Color Cast An overall bias of a single color, to an image, camera or monitor. May or may not be intentional. Examples include sepia toning, uncorrected tungsten lights on daylight film and tobacco filters.

Color Grading Adjusting the color balance and contrast of an image to compensate for unwanted flaws or deficiencies in a capture or conversion process, so that the image will more closely matches the original. Examples of flaws are overexposure, underexposure, or colorcasts and flaws include limited dynamic range or a change of color space. The goal is to achieve the “natural image”.

Color Enhancement A change to the image that does not necessarily reflect reality, but which is intended to add emphasis or meaning to the image. The colorist often uses shapes, keys, mattes and more specific tools to modify the “natural image” for aesthetic style, emotional value and visual impact. The term usually refers to digital post production tools rather than film lab systems. Enhancements may or may not be planned at the shooting stage.

Color Temperature The precise measurement of light, in degrees Kelvin (K) which represents the color of light emitted by a black body when heated to that temperature. Tungsten light is about 3200K, skylight can be upwards of 10,000K. The black body curve used to measure color temperature is a range between red and blue two lights of the same color temperature can look different by containing more or less green. Warmer color temperatures are lower. Cooler temperatures are higher.

Contrast A term referring to how far the whitest whites are from the blackest blacks. , "Contrast" is the general term for the property called "gamma" (Y). If the peak white is far away from the peak black, the image is said to have high contrast. With high contrast, the image is very stark and very "contrasty", like a black-and-white tile floor. If the two are very close to each other, the image is said to have poor, or low, contrast and looks gray.

Digital Intermediate The process of manipulating color and other characteristics of digital images prior to theatrical release. It is similar to the telecine process which is intended for video and television formats. DI is currently used for both film and video markets and typically involves software and a data workflow rather than hardware and a tape based pipe line.

Display - Diamond Allows you to determine which colors are contributing to Gamut errors in the RGB domain.

Display – RGB Parade A waveform display of the video levels for Red, Green and Blue components. Where the signals are paraded side by side next to each other in RGB order.

Display - Spearhead Allows you to perform color adjustments in terms of lightness, saturation and value.

Display - LQV Allows you to see color cast in specific luma ranges (highs, lows, or mid-tones).

Dynamic A gradual change. Usually a dynamic is defined by two or more keyframes which determine start and end values and allow in between frames to be calculated (color) or generated (animation). In color grading a dynamic is a gradual change of parameter values over a number of frames. The term is sometimes used (misleadingly) to mean an edit transition such as a dissolve.

Dynamic Range 1) The difference between the brightest and darkest parts of an image. 2) The brightest and darkest detail a capture medium can record.

Flat 1) Low contrast. Flatness does not necessarily affect the entire density scale to the same degree. Thus, a picture may be "flat" in the highlight areas, or "flat" in the shadow regions, or both. 2) A video transfer is said to be "flat" if it remains the same as the original and no changes or enhancements are applied.

Gain 1) The adjustment of highlight information (telecine). 2) The ratio of output signal to input signal of any electronic processing.

Gamma Since picture monitors have a nonlinear relationship between the input voltage and brightness, the signal must be correspondingly pre-distorted. Gamma correction is always done at the source (camera) in television systems: the R, G, and B signals are converted to R 1/g, G 1/g, and B 1/g. Values of about 2.2 are typically used for gamma. Gamma is a transfer characteristic. Display devices have gamma (or at least CRTs do). If you measure the actual transfer characteristic of a CRT used for either television display or computer display, you will find it obeys a power law relationship:

$$\text{Light} = \text{Volts}^{\gamma}$$

where gamma is 2.35 plus or minus 0.1. CRTs have values between 2.25 and 2.45, 2.35 is a common value. It is a function of the CRT itself, and has nothing to do with the pictures displayed on it. CRT projectors are different, green tubes are typically 2.2 while red is usually around 2.1 and blue can be as low as 1.7. But there are no direct-view CRTs which have values lower than 2.1. Pictures which are destined for display on CRTs are gamma-corrected, it means that a transfer characteristic has been applied in order to try to correct for the CRT gamma. Users of TV cameras have to accept the characteristic supplied by the manufacturer, except for broadcasters who have adjustable camera curves (the video engineers adjust the controls until they like the look of the picture on the studio monitor in their area). Even so, no TV camera uses a true gamma curve, they all use rather flattened curves with a maximum slope near black of between 3 and 5. The higher this slope, the better the colorimetry but the worse the noise performance.

Gamut The range of voltages allowed for a video signal, or a component of a video signal. Signal voltages outside of the range (that is exceeding the gamut) may lead to clipping, crosstalk, or other distortions.

Gamut Displays Tektronix proprietary displays for monitoring gamut: Diamond, Spearhead and Arrowhead.

Hue The property of light that discriminates one color from another.

Illegal Video A video signal that falls outside the appropriate gamut for that format. For instance, the gamut limits for an R', G', B' signal are 0 mV to 700 mV and Y' is 0 mV to 700 mV and P'b/P'r are +/-350 mV. If the signal falls outside of these limits it is an illegal value.

Latitude The range of exposure a film stock can tolerate and still give substantially correct reproduction.

Legal Signal A signal in which each component remains within the limits specified for the video signal format; that is, it does not exceed the specified gamut for the current format. For instance, the gamut limits for an R', G', B' signal are 0 mV to 700 mV and Y' is 0 mV to 700 mV and P'b/P'r are +/-350 mV. If the signal remains within these limits the value is legal.

Legal Color Limiting Method of clipping an electronic signal to conform to user defined maximum and minimum levels.

Low Key A scene is low key if the tonal range of the reproduction is mostly in the high density (shadow) range of the process and contains few mid tones or highlights.

Luminance The black and white, or brightness, part of a component video signal.

Monochrome An image consisting of only one color. Often used to mean Black and White.

Pluge "Picture Line Up Generating Equipment". Now used to mean a specific test pattern used to align the brightness of monitors. The pattern consists of black at -2%, 0% and +2%, and black, mid gray and white patches.

Primary Grading In colorist terminology "primary" gradings are those that affect the overall color balance of an image. The da Vinci 888 provides 64 Bit four channel (YRGB) Primary processing. Others refer to telecine gradings as "primary" and external gradings, such as those from a da Vinci as "secondary".

Saturation A measure of the dilution of a pure color with white light. The amount of color in a picture.

R, G, B Color Space A) An additive color space with colorimetric coordinates based on red, green, and blue stimuli or primaries. Color values are negative in certain areas outside the gamut defined by the R, G, B primaries. The R, G, B values used are intensities. B) The three linear video signals carrying respectively the red, the green, and the blue information. By convention the unprimed symbols signify that there is a linear relationship between the luminance in each spectral region and the corresponding video signal. The spectral composition of the luminance forming each of these signals is one of the specifications required of the video system. The recently adopted CCIR Rec 709 reflects worldwide agreement on the current definition of R, G, B primary colors. CCIR Rec 709 identifies this as an interim agreement to be superseded by preferred primary colors encompassing a wider color gamut as soon as the technologies and practices permit.

C) The colorimetric coordinates defined by three nonlinear video signals carrying respectively the red, the green, and the blue information. By convention the primed symbols signify that there has been a nonlinear transformation of the video signals vs. luminance, relative, scene, with its resulting modification of the opto-electric transfer function.

Secondary Grading Color grading that affects only affect a specific color range within an image or a specific geographic region within an image (like a vignette or "window.")

Specular Highlights A very bright highlight reflecting from a highly reflective surface, such as glass, chrome, metal, highly polished surfaces or water.

Telecine A device that scans images from motion picture film, usually in real time. Telecines were originally designed for video transmission, and pre date VTRs. Modern telecines also output data at resolutions up to 4k.

Thin As applied to a negative, having low density, usually as a result of underexposure. The image from a thin negative will be very dark, with little or no shadow detail. Stretching the contrast will enhance film grain.

Waveform Monitor & Rasterizer A Tektronix waveform monitor is an instrument to measure or monitor video or audio signals – and may or may not include an integrated display. A WFM waveform monitor series has an integrated display that is ideal for space constrained environments. A WVR series

rasterizer requires an external display to view the waveform displays.

White Balance Compensation for tints caused by ambient light. In simplest terms it is defined as daylight or tungsten but most digital cameras can be more accurately calibrated.

Glossary compiled with the help of Kevin Shaw;
www.finalcolor.com

For additional Video terms, click here to download [Tektronix' Video Glossary](#).

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