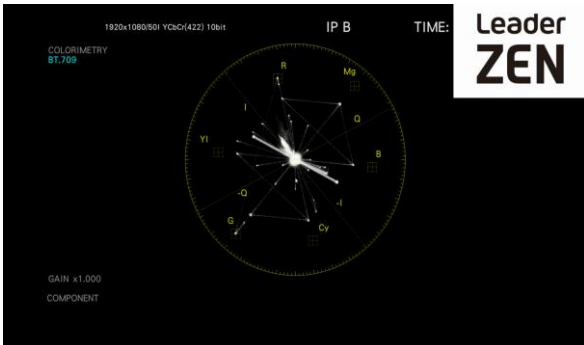


Leader

Leader Electronics Corporation Technical Information

Leader – An Introduction to

Vectorscope Displays



Leader ZEN



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Table of Contents

Notice..... 2

Release Notes:..... 2

Leader – An Introduction to Vectorscope Displays..... 4

What is the purpose of the Vectorscope Display? 4

 Figure 1 - Vectorscope Display 4

 Figure 2 - Vectorscope Display – Colour Bars 5

Understanding the Vectorscope Display?..... 6

 Figure 3 – Vectorscope - Trace..... 6

 Figure 4 – Simulated Vectorscope with Colour Wheel..... 6

 Figure 5 – Vectorscope Markers..... 7

 Figure 6 – Vectorscope – Hue – Red, Green and Blue..... 7

 Figure 7 – Vectorscope – Saturation..... 8

 Figure 8 – Vectorscope – 75% Colour Bars 8

 Figure 9 – Vectorscope – 100% Colour Bars 9

What are the U & V axis? 10

 Figure 10 – Vectorscope – U & V Axis 10

What are the I & Q axis?..... 11

 Figure 11 – Vectroscope – Red / Orange Range..... 11

 Figure 12 – Vectroscope – I /Q Axis 11

 Figure 13 – Vectorscope – Marker Display 12

What ARIB Check Markers? 13

 Figure 14 – ARIB STD-B66 / B72 Markers 13

How to use a Vectroscope Display? 14

 Figure 15 - Vectorscope Display and Picture 14

 Figure 16 - Vectorscope Display and Picture Line No. Display 15

Vectorscope Display - Colour Matrix 15

 Figure 17 - Vectorscope Displays Colour Matrix..... 15

Vectorscope Display – MAG (GAIN)..... 16

 Figure 18 - Vectorscope Display – GAIN MAG..... 16

 Figure 19 - Vectorscope Display – GAIN MAG and Guide Display..... 16

So, how do you use a vectorscope display? 17

Camera Colour matching..... 17

 Figure 20 – Camera Colour - Adjustment..... 17

Vectorscope Display and Skin Colour..... 18

 Figure 21 – Skin Tone - Adjustment..... 18

Leader ZEN Series- Test and Measurement..... 19

Leader – An Introduction to Vectorscope Displays

The Leader 'An Introduction to ...' is part of a series of tutorials in which the fundamental principles of video and audio test and measurement will be explained.

This tutorial focuses on the vectorscope display, its origins and how it is used in film and television production.

For those unfamiliar with the vectorscope display, it can appear confusing and complicated, with a rapidly moving trace dancing between a myriad of lines and markers on a graticule display, but once you get to know and understand how to use the vectorscope display, it will prove you with an invaluable instrument for television and film production.

What is the purpose of the Vectorscope Display?

- The vectorscope complements the waveform display for the purpose of measuring and testing television signals, regardless of the format.
- While a waveform display allows a broadcast technician to measure the overall characteristics of a video signal, a vectorscope is used to visualise chrominance, which is encoded into the video signal.

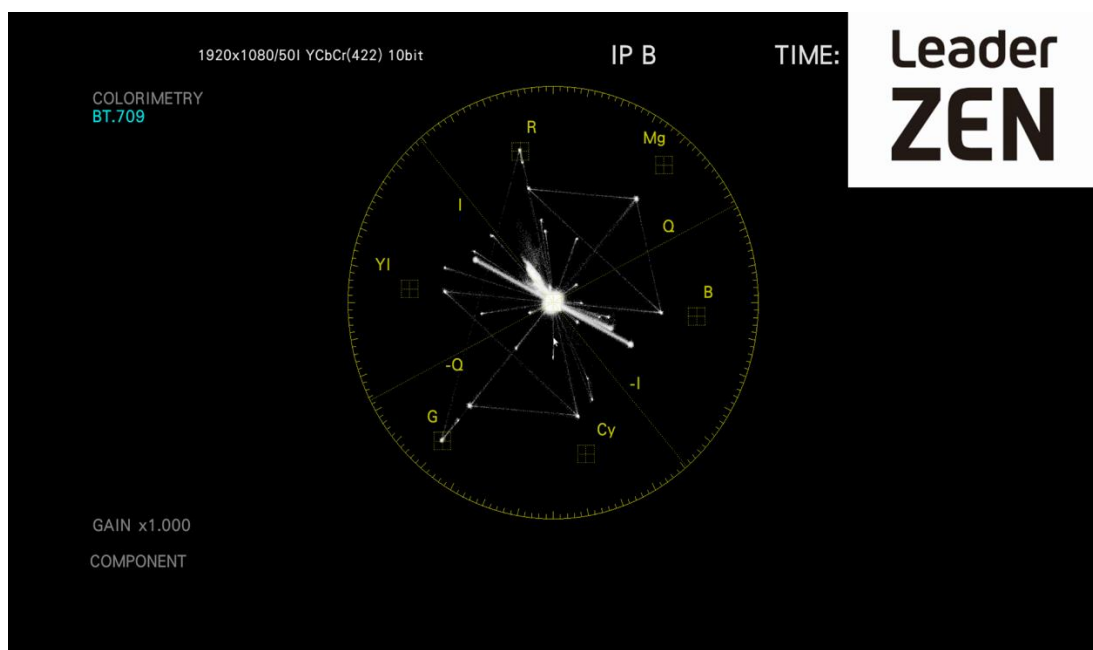


Figure 1 - Vectorscope Display

- In digital applications, a vectorscope instead plots the Cb and Cr channels against each other (these are the two channels in digital formats which contain chroma information)
 - As the vectorscope only operates with Cb and Cr signals, RGB has to be converted to Cb Cr to be displayed on a vectorscope display.
 - There is no luminance component displayed.
- So how does a picture translate into a vectorscope display?
- A 75% colour bars test pattern translates into the following trace on the vectorscope display.
- As the vectorscope plots the Cb and Cr channels against each other, here you can see from the Cb and Cr waveform displays how they result in the vectorscope display.

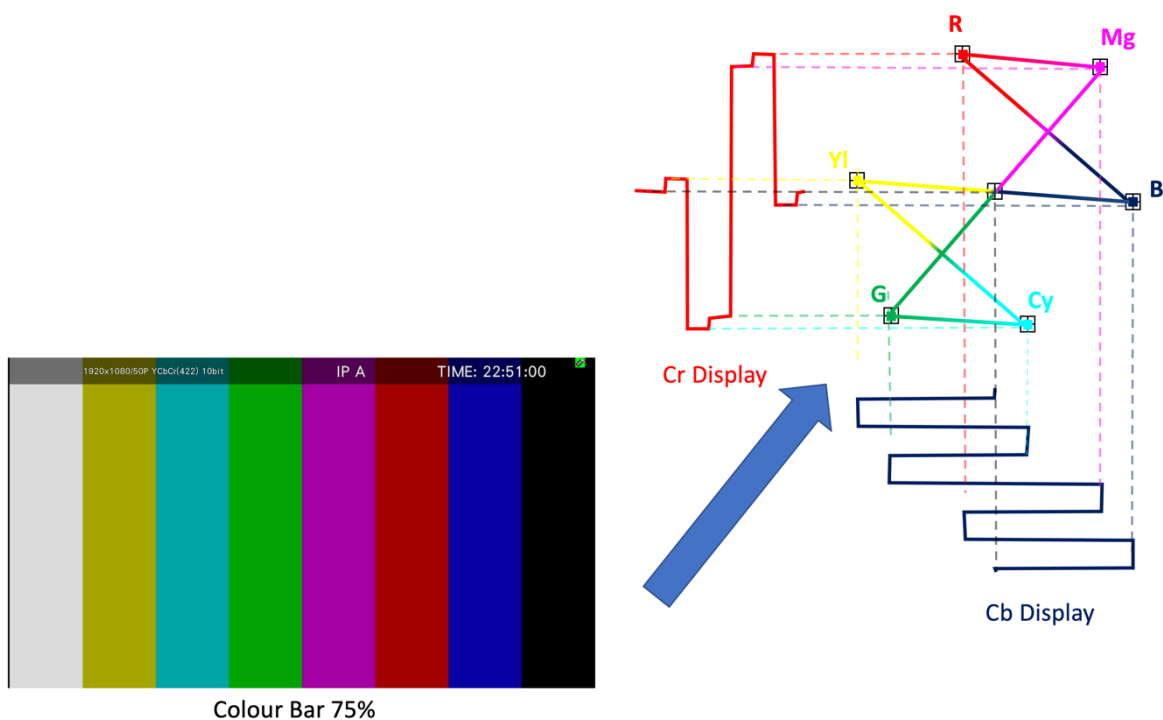


Figure 2 - Vectorscope Display – Colour Bars

Understanding the Vectorscope Display?

The actual visual pattern that the incoming chrominance signal draws on the vectorscope is called the trace and the 75% colour bars test pattern translates into the following trace on the vectorscope display.

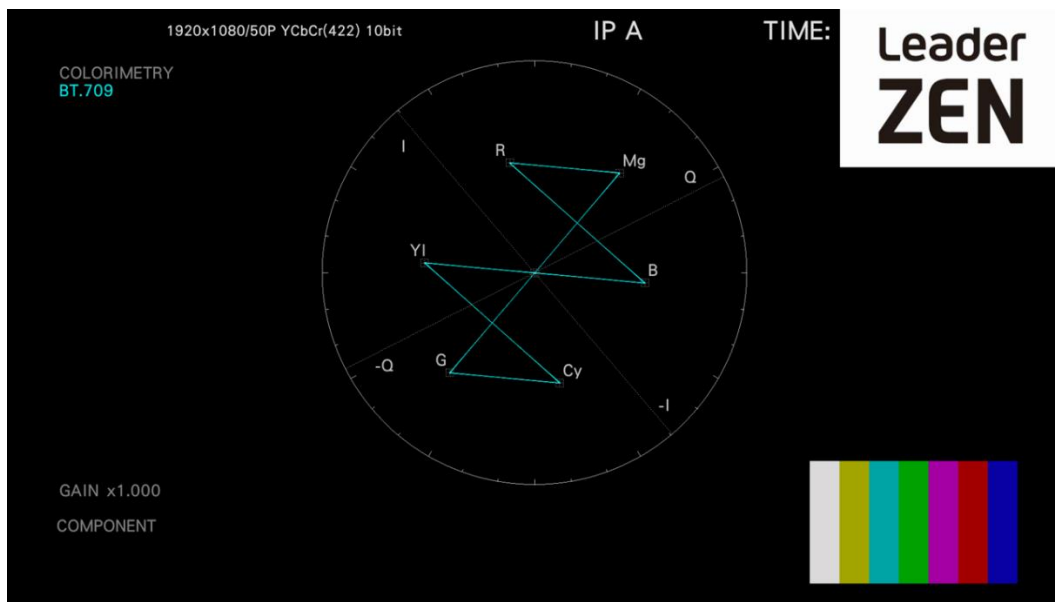


Figure 3 – Vectorscope - Trace

To assist us in explaining how to interpret the Vectorscope display, we have added to the vectorscope display a Colour Wheel around the periphery of the vectorscope graticule.

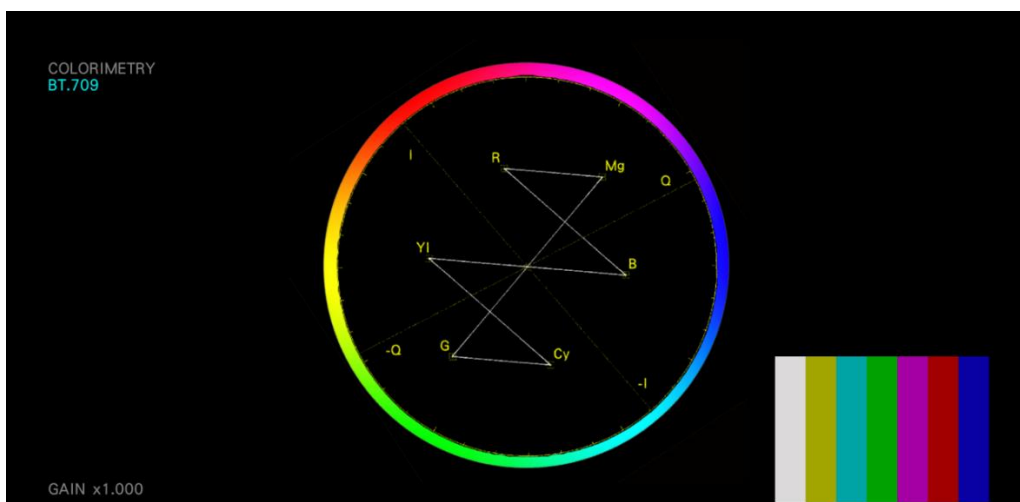


Figure 4 – Simulated Vectorscope with Colour Wheel

Each of the markers on the graticule indicates the location of the Red, Green, Blue Primaries and Cyan, Yellow and Magenta Secondary colours.

The centre of the graticule is no colour.

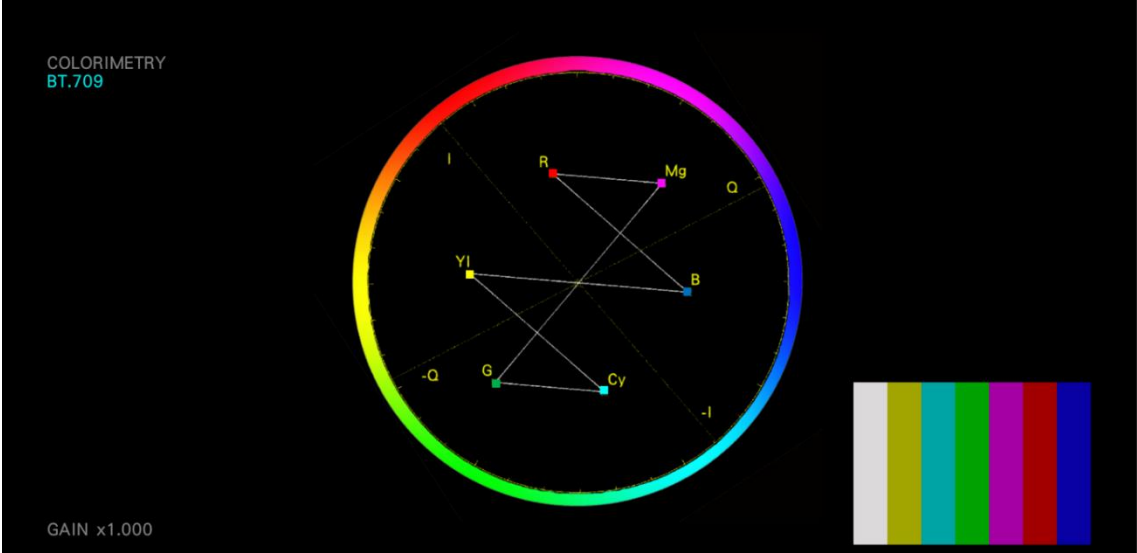


Figure 5 – Vectorscope Markers

Hue defines colour on the basis of its position in the spectrum.

- The vectorscope display starts with the Red Primary at 0°, passing counter-clockwise through the Green Primary at 120° and the Blue Primary at 240° and then returning to Red at 360°.

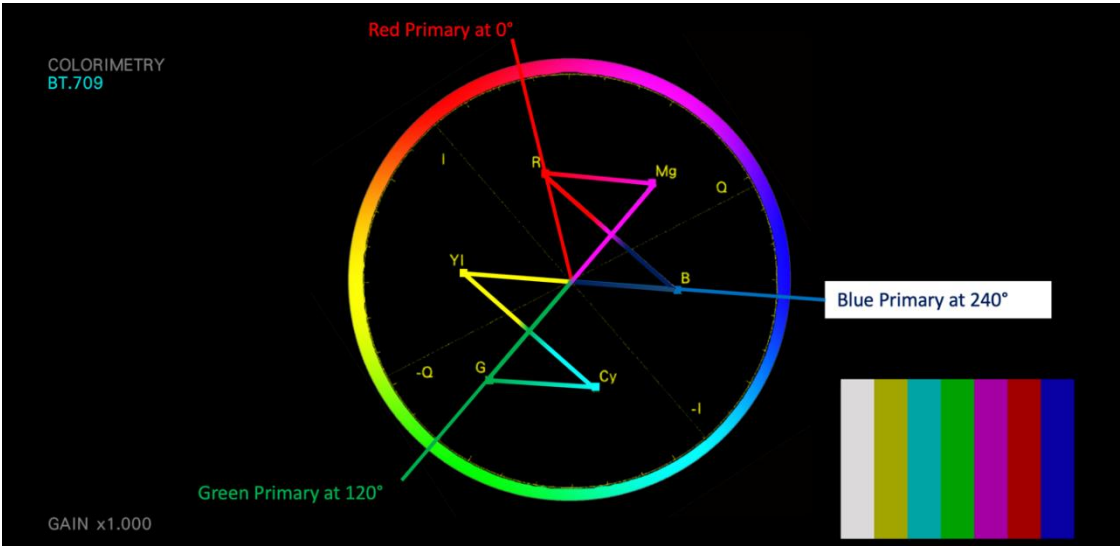
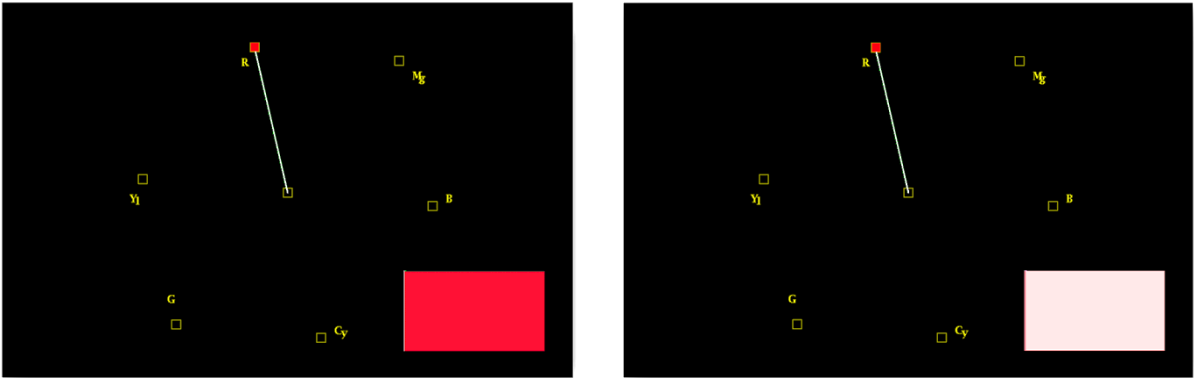


Figure 6 – Vectorscope – Hue – Red, Green and Blue

Saturation defines the intensity of the colours in the active picture. A 100% saturated colour does not contain any white and by adding white it reduces the saturation. In Video, adding white will desaturate the colour, but white does not show up on a vectorscope display.

In this case, the picture on the right has been desaturated by adding white however, the vectorscope trace still shows the same display as the picture on the left, but you will notice that the desaturated picture looks Pink instead of bright Red.



100% Saturated

75% Saturated (25% White added)

Figure 7 – Vectorscope – Saturation

The Leader ZEN Series vectorscope graticule includes target markers for the primary and secondary colours and can be configured to display either 75% colour bars or 100% colour bars. The 75% colour bars are 100% saturated, just 75% in levels.

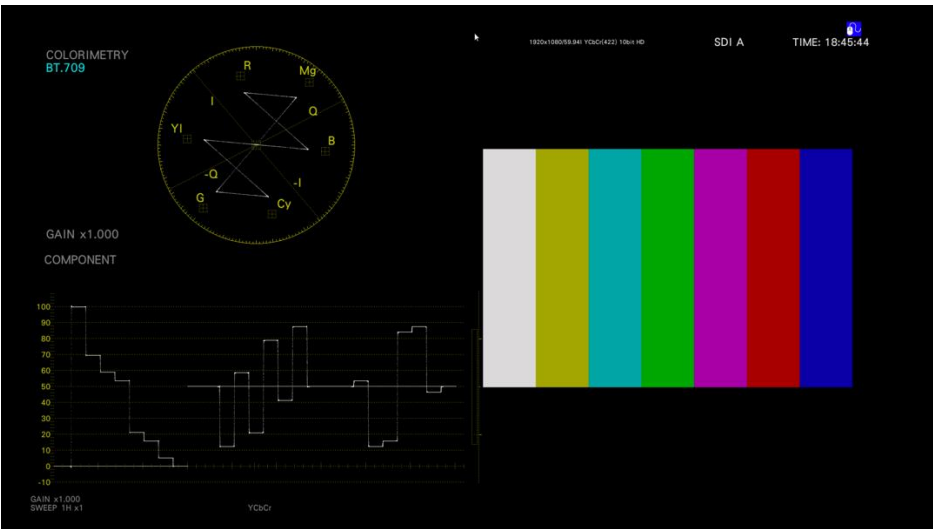


Figure 8 – Vectorscope – 75% Colour Bars

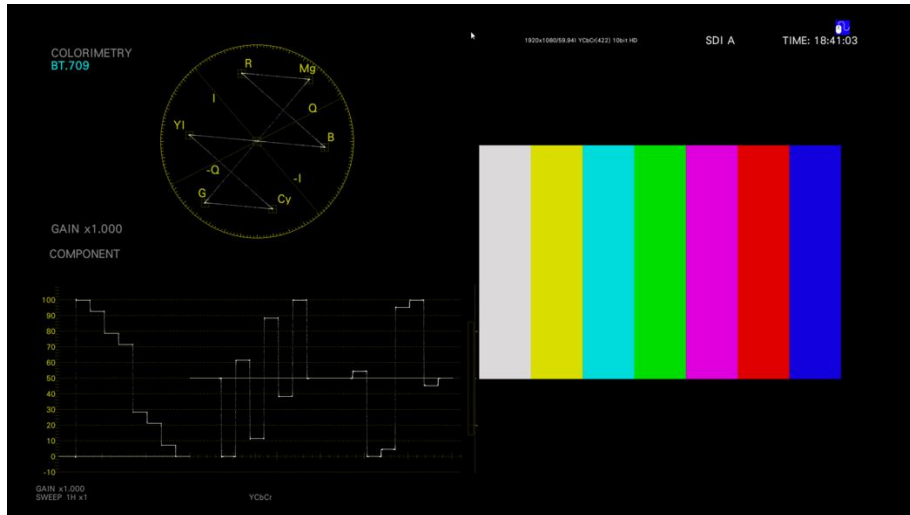


Figure 9 – Vectorscope – 100% Colour Bars

The first colour bar signals were, in fact, 100% amplitude. However, these put quite a strain on the services that routed the video signal because the peak chroma excursion for 100% bars reached 133 IRE units. And since fully saturated 100% amplitude chroma signals are simply not encountered in nature (they don't come out of cameras) it was decided that a more realistic approach would be to reduce the amplitude of the RGB signals into the encoder to 75%.

However, 100% bars may be encountered from time to time and since phase angles remain the same in either case, it is only necessary to change the gain of the XY amplifiers to accommodate both.

What are the U & V axis?

The perpendicular lines corresponding to the U and V components of the chrominance signal.

- U – Is one of the two colour difference signals that modulate subcarrier in the PAL system. U corresponds to weighted B-Y. The formula for deriving the U signal is $.493(B-Y)$
- V – Is one of the two colour difference signals that modulate subcarrier in the PAL system. V corresponds to weighted R-Y. The V component of subcarrier is reversed in phase on alternate lines. The formula for the V signal is $.877 (R-Y)$.

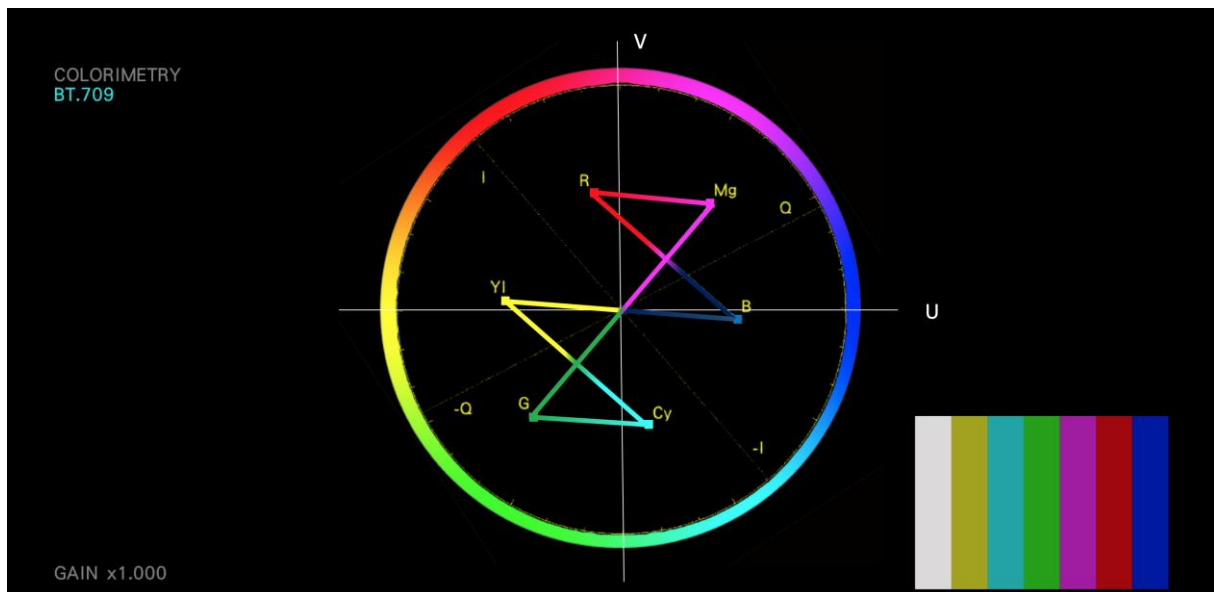


Figure 10 – Vectorscope – U & V Axis

What are the I & Q axis?

Broadcasts require that the signals be encoded on the I and Q axis. These are a pair of modulation axes 90° from one another but rotated some 33° counter-clockwise from the R-Y (U)/B-Y (V) axis.

The reason why the I and Q axis are rotated 33° counter-clockwise from the R-Y (U)/B-Y (V) axis is because the human eye does not respond uniformly to all colours, we see colour detail best in the red / orange range. This also places 'skin tone' measurements directly on the 'I' axis. *(This will discuss in more detail later.)*

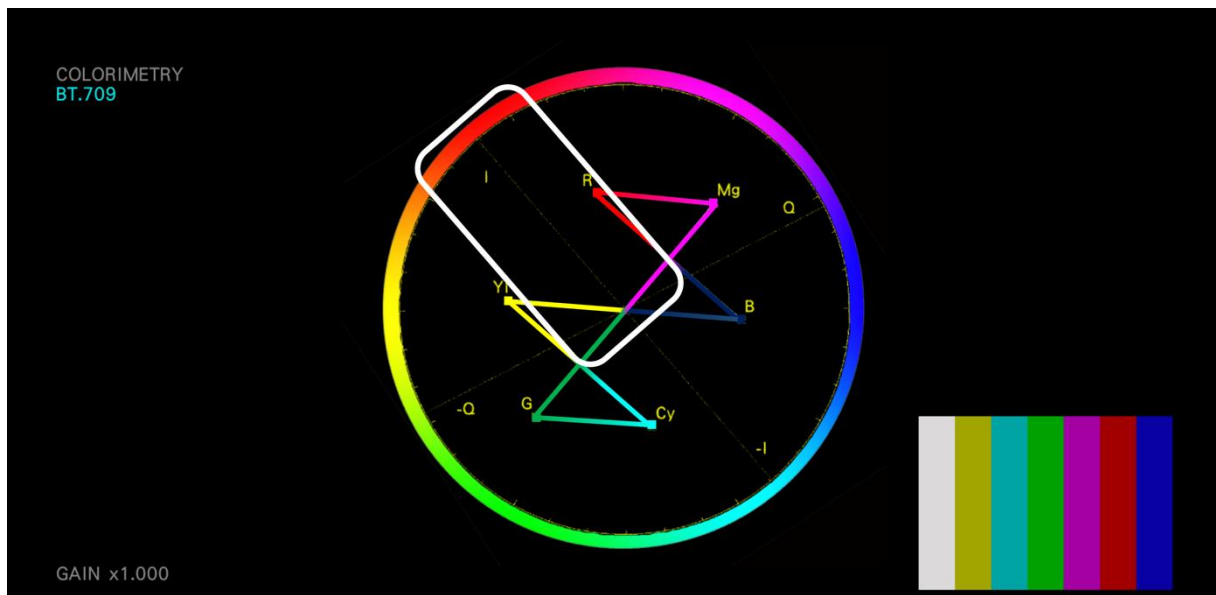


Figure 11 – Vectroscope – Red / Orange Range

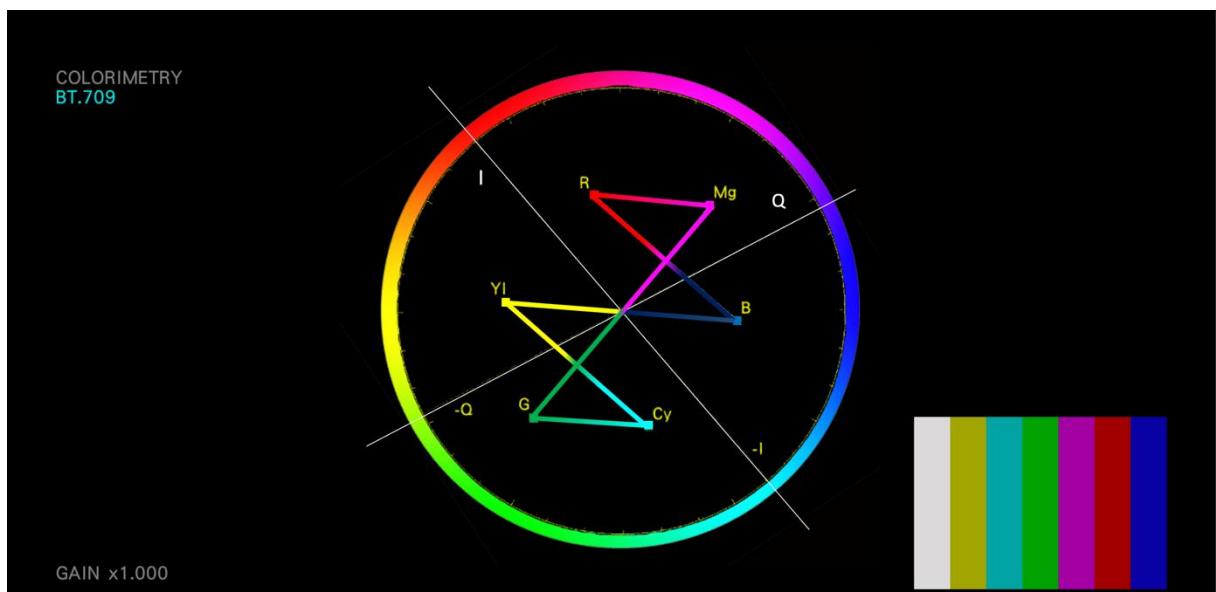


Figure 12 – Vectroscope – I / Q Axis

- I – In phase axis is a designator used to name one of the colour components of the NTSC video signal. The formula for deriving I from red, green and blue is $.60R - .28G - .32B$.
- Q – Quadrature axis is in quadrature with the I axis and is a designator used to name one of the colour components of the NTSC video signal. The formula for deriving Q from red, green and blue is $.21R - .52G - .31B$.

The Leader ZEN Series also supports a marker display, which allows you to move the cursor on the vectorscope trace and display

- **d** – Distance from the center as a percentage.
- **Deg** - Hue as an angle
- **Cb** – CB position as a percentage
- **Cr** – CR position as a percentage

To give you accurate measurement capabilities.

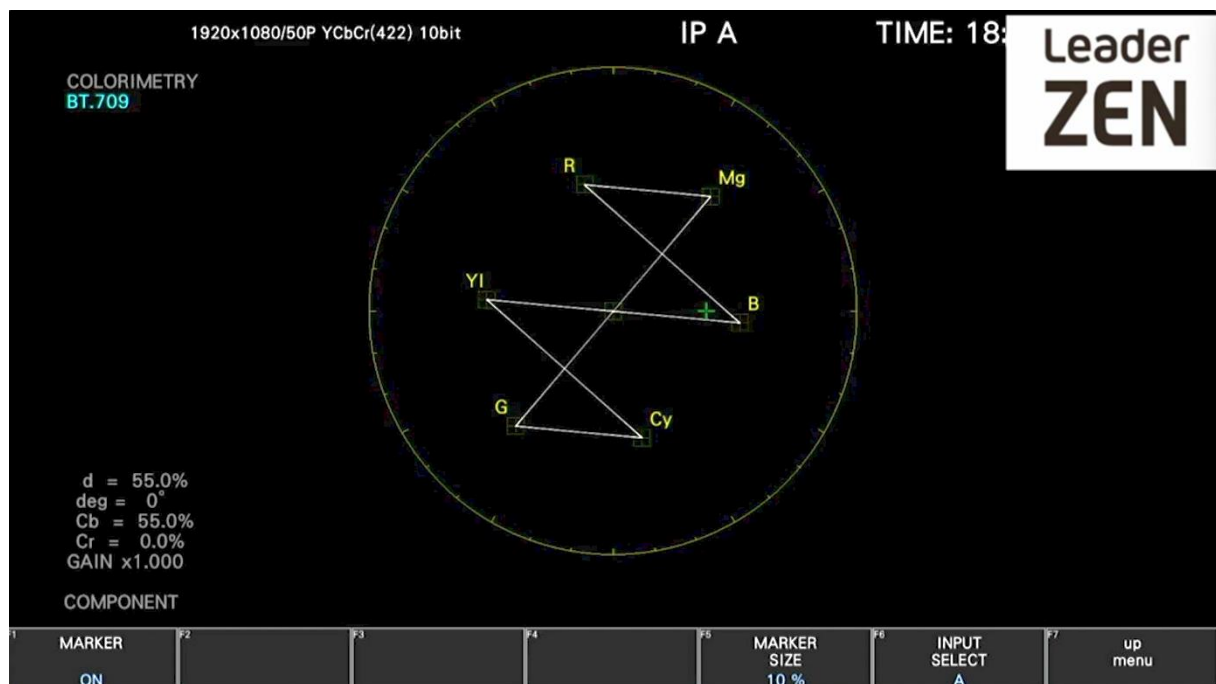


Figure 13 – Vectorscope – Marker Display

What ARIB Check Markers?

With the introduction of UHDTV resolutions broadcasters can utilise a new wider colour space Rec .2020. The Rec. 2020 (UHDTV/UHD-1/UHD-2) colour space can reproduce colours that cannot be shown with the Rec. 709 (HDTV) colour space.

This has resulted in ARIB publishing a new colour bars test patterns that support both Rec. 709 and Rec. 2020.

The Leader ZEN Series supports display of both the ARIB STD-B66 and STD-B72 markers on the vectorscope graticule.

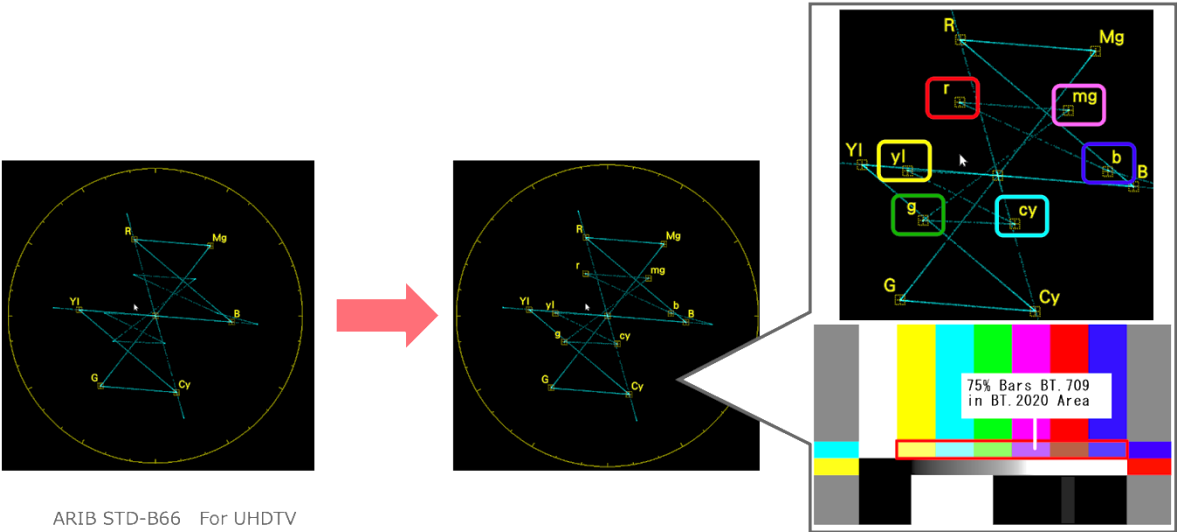


Figure 14 – ARIB STD-B66 / B72 Markers

How to use a Vectroscope Display?

So now that we understand the information being displayed by the vectorscope, let's see how it can be used in day-to-day television and film production.

The Leader ZEN Series can simultaneously display the vectorscope and picture image.



Figure 15 - Vectroscope Display and Picture

The vectorscope display also supports the capabilities to zoom in to show individual lines of the video signal.

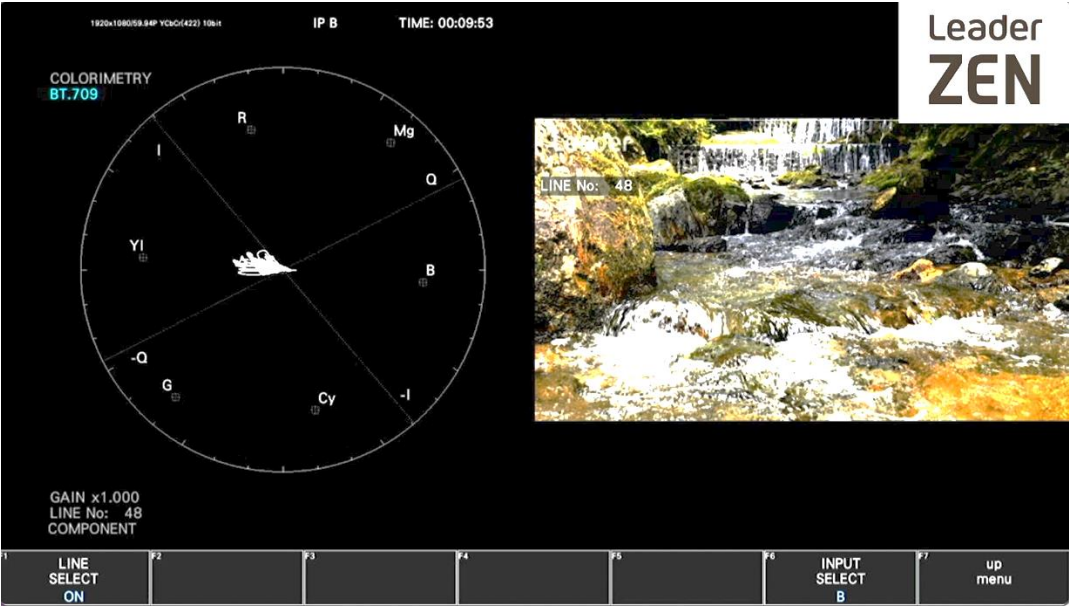


Figure 16 - Vectorscope Display and Picture Line No. Display

Vectorscope Display - Colour Matrix

The vectorscope display also supports both composite and component colour matrix display. The composite format allows NTSC, PAL or automatic selection.



Figure 17 - Vectorscope Displays Colour Matrix

Vectorscope Display – MAG (GAIN)

The vectorscope display can also be magnified with GAIN applied to the input signal in either x1, or x5 along with a variable adjust up to x2.



Figure 18 - Vectorscope Display – GAIN MAG

A marker display window can also be enabled to allow the operator to locate exactly where on the vectorscope graticule the trace being displayed is located.



Figure 19 - Vectorscope Display – GAIN MAG and Guide Display

So, how do you use a vectorscope display?

Camera Colour matching

We need a vectorscope display to adjust the camera's colour imagery before commencing a shoot.

And this achieved by using the vectorscope display and a colour bars test pattern chart.

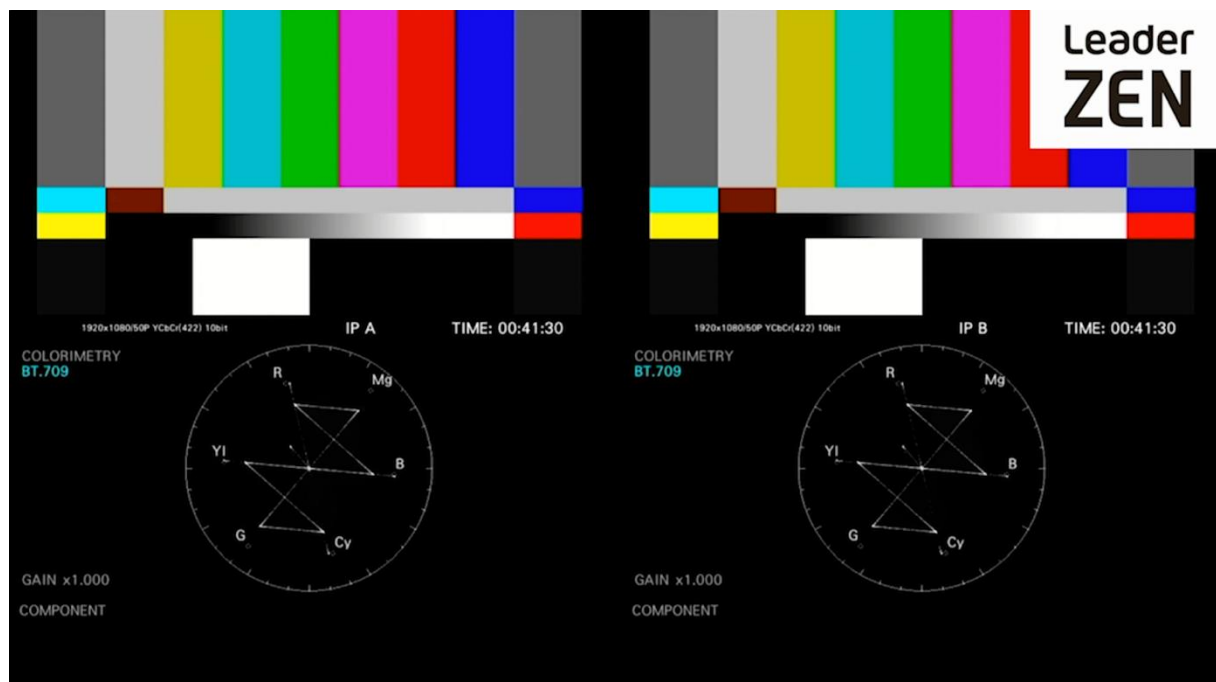


Figure 20 – Camera Colour - Adjustment

The Leader ZEN Series vectorscope display also features the ability to adjust the gain on the vectorscope display.

The reason for this is that unlike an electronically generated colour test pattern the camera can only produce 50% of the amplitude that the colour bars have, so a calibrated amount of gain needs to be added to the vectorscope display. Typically, this is 2x gain, so the colours from the camera colour test chart appear correctly positioned in the Primary and Secondary colours markers on the vectorscope display.

This will ensure that the two cameras colour imagery matches identically, and you will not have to carry out corrective work in postproduction.

Vectorscope Display and Skin Colour

Images that include people can be some of the most challenging to setup correctly and camera match. The main reason for this is that the human brain is used to seeing people every day and knows exactly what skin colours looks like, the other challenge we face is that people have different colour skins.

Now we think of melanin as the main determiner of skin colour, but it's the blood under our skin that affects the hue. Melanin mostly affects brightness and saturation, we all have the same blood, so we all have the same hue.

A person's **skin colour** is determined by the amount of melanin in his or her **skin**. Melanin is a dark brown to black pigment produced by special cells called melanocytes. ... People with darker **skin** have more melanin. People with yellow **skin tones** have more or another type of pigment called carotene.

But hold on a minute, doesn't the vectorscope display hue? So, if that's the case, can't we use the vectorscope display to correct adjust the image for skin tone?

Earlier on in this paper, we discussed the I & Q axis and conveniently skin colour displays a trace along the I axis as can be seen from the vectorscope display on the skin tone bar chart, all the various skin tones from the left to the right appear around the I Axis.

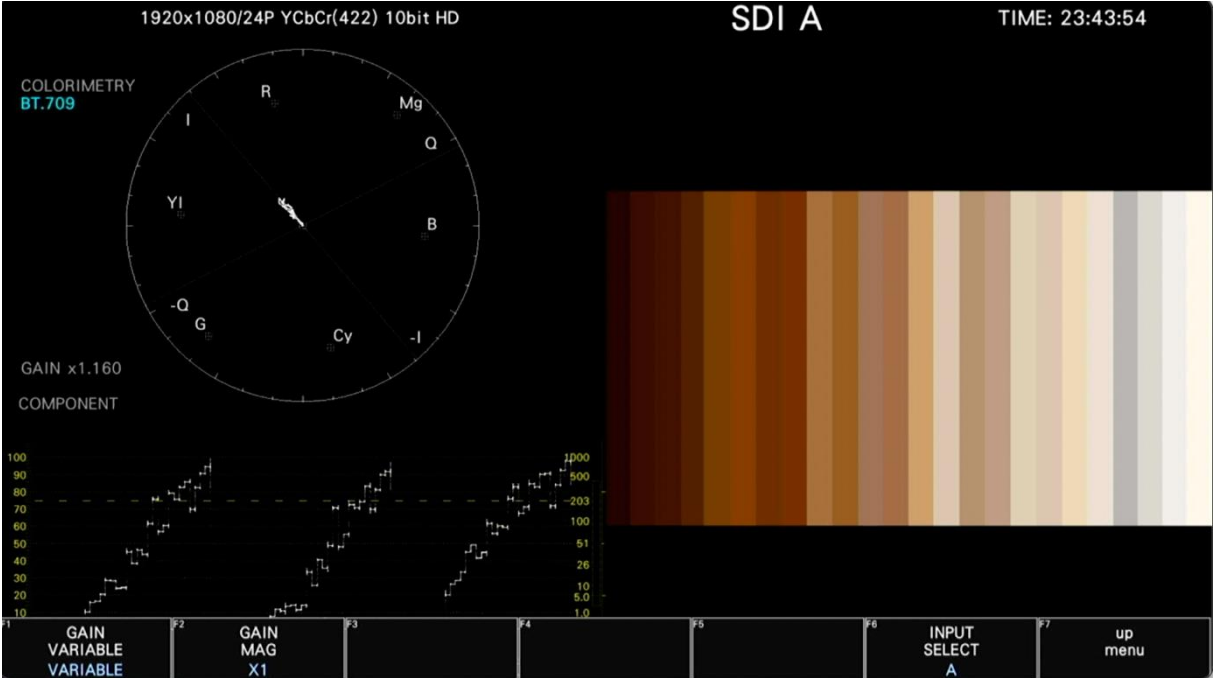
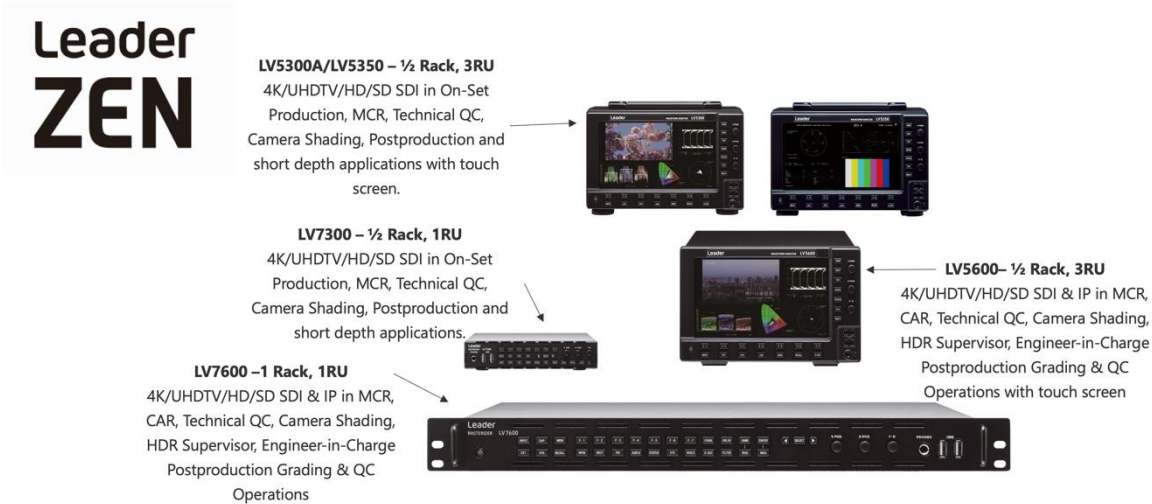


Figure 21 – Skin Tone - Adjustment

This is an extremely useful feature if you are working in a live production environment or colour grading images that include skin tone. Simply adjust the image, so the skin tone in the image is close to the I Axis, then you can carry out the other adjustments as required.

Leader ZEN Series- Test and Measurement

The vectorscope display features described in this white paper are available on all Leader ZEN Series waveform monitors and rasterizers.



The video that accompanies this tutorial can be viewed on the

 : [Leader Europe YouTube Channel](#)

About the Author

Kevin Salvidge, European Regional Development Manager, Leader Europe Limited, has over 20 years of broadcast industry experience. He joined Marconi Instruments in 1982 as an apprentice, later becoming a field service engineer. In 1994 he progressed to Sony Transcom as a field service representative before moving into sales roles with Tektronix, Grass Valley, Thomson Multimedia, Sony and Omneon.



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