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APPLICATION NOTE 3416

# Visual Impact of Video Parameters in Video Systems: Part 1—Differential Gain and Differential Phase

*The ultimate measure of quality in video systems is largely determined by visually looking at the resulting picture. But it is also very beneficial to have objective measurements for judging quality. Of all the electrical measurements for video, differential gain (dG) and differential phase (dP) are often the best for determining the quality of the system. This article will help the reader understand the relationship between the dG/dP measured values and their impact on the video picture's quality.*

## Introduction

To maintain good video performance in systems that process composite video signals (CVBS), two important parameters stand out above the others: differential gain and differential phase, usually abbreviated as dG and dP. This CVBS signal combines the chrominance (color) information and the luminance signal (brightness) to form a common composite video signal. This composite form of a video signal is the standard used to modulate the RF signal distributed as normal broadcast TV, and is important for reducing the required transmission bandwidth. In addition, CVBS allows a simple one-wire connection for baseband video.

## Differential Gain and Differential Phase

Differential gain is the percentage of color saturation variation when the luminance changes. Differential phase is the variation of the hue (phase of the color) when the luminance changes. In an ideal system, the color should not change its saturation or hue when brightness changes. Thus the values for dG and dP are ideally zero. In practical systems, however, the dG and dP values are not zero, with the smaller number the better. The dG measurement unit is percentage (%), and the dP measurement unit is degrees.

Typical studio-quality video dG/dP values range from 0.001%/0.001° to 0.2%/0.2° respectively. For consumer-quality video, these figures typically range from 0.5%/0.5° up to 5%/5° for dG/dP respectively. Studio-quality values are significantly lower than the corresponding consumer values because the typical studio-broadcast signal will be subjected to many different, successive video-processing steps, with each step contributing its own error. The design goal is, therefore, that the cumulative error not limit the overall broadcast system performance.

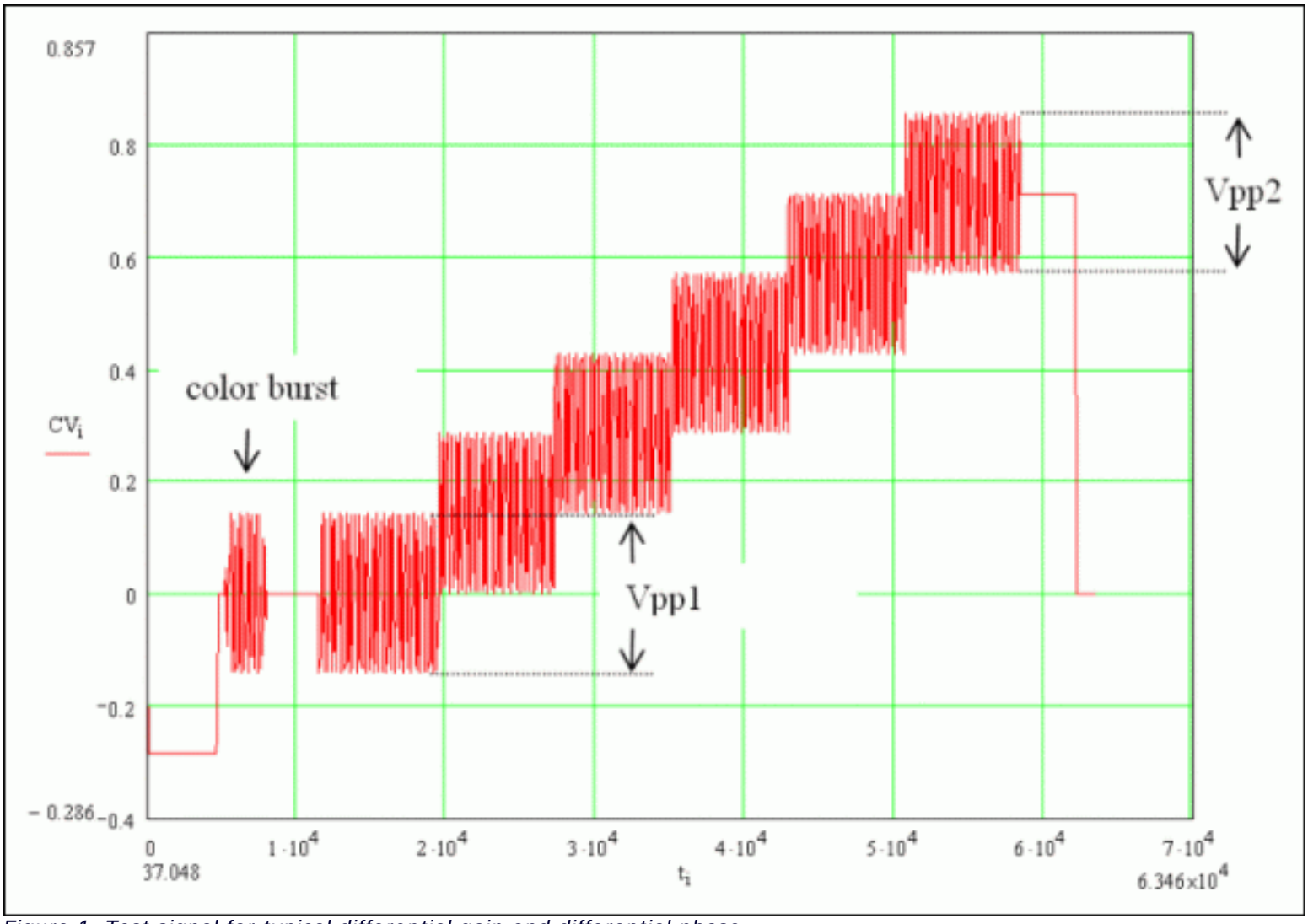


*Figure 1. Test signal for typical differential gain and differential phase.*

Differential gain and differential phase are usually measured using the modulated 5-step staircase signal shown in **Figure 1**. Differential Gain is defined as the ratio of Vpp1 to Vpp2 multiplied by 100%. Differential Phase is defined as the difference in the peak-to-peak phase variation of these color steps compared to the color burst phase.

With today's modern video test equipment, such as the Tektronix VM700, these parameters can be measured with a press of a button. However, visualizing the effect of these parameters is vitally important. A presentation of such effects follows.

## Visual Effect of Video System with a Large dG

The picture in **Figure 2** simulates a red colored, 5-step staircase signal. As the luminance level changes from dark to bright, it is desirable that the color saturation remains constant with the change in brightness. Stated more simply, one wants the amount of color to stay constant with brightness changes. This is illustrated in the upper portion of Figure 2. You can see the bright red color in the last column on the right where brightness is at its highest level. If, however, color saturation changes when the luminance is at its highest level, then incorrect color saturation results. This is evident in the "washed-out" red of the last column in the lower portion of the figure.

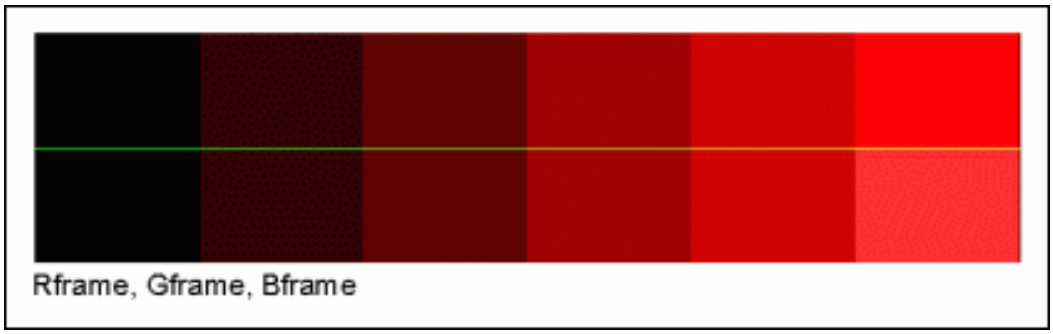

*Figure 2. Visual effect of differential gain.*

## Visual Effect of Video System with a Large dP

As with differential gain, it is also desirable for the phase to remain constant as the luminance level changes from dark to bright. This is shown in the top portion of **Figure 3**. Remember that a change in phase causes a change in hue. If the hue (phase) changes when the luminance is at its highest level, then an incorrect color results. Here the 'red' in the lower half, last column appears to be an orange color instead of the desired red.

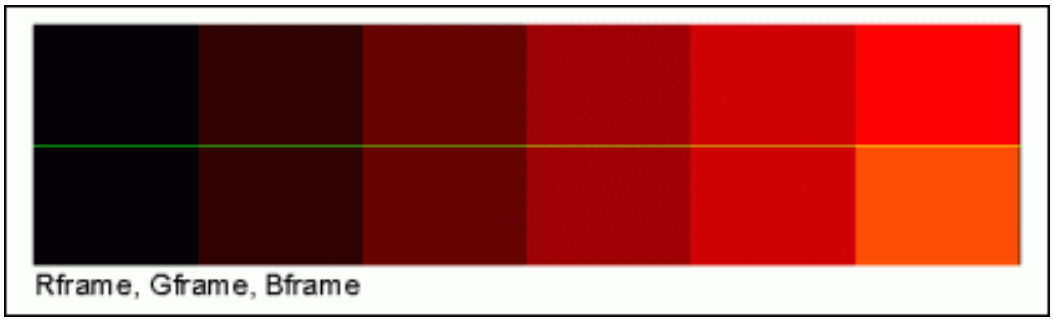

*Figure 3. Visual effect of differential phase.*

## Conclusion

The above examples use 20% differential gain error and 19° differential phase error to dramatically illustrate the visual effect of these errors on displayed pictures. For most video systems the errors will typically be less than these values. However, it is vital to understand that even small errors will degrade the quality of the picture. This is especially apparent in normal video material. Therefore, it is very important for the video systems designer to pay close attention to the dG and dP parameters and ensure that they are kept as low as possible. Video pictures look vivid and enjoyable when all intended colors are reproduced correctly.

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