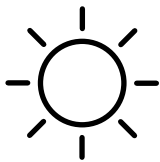


“Black Level” and “Picture”

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This note introduces the two main user adjustments of a video monitor, *Black Level* and *Picture*. I explain the effect that these controls have on picture reproduction, and I explain how to set them. This note applies to computer video monitors, studio video monitors and television receivers, and applies to both grayscale and color monitors.

These two controls are sometimes called *Contrast* and *Brightness*, and those labels are still found on many television sets. Unfortunately, those labels are misleading with respect to their functions: the control called “brightness” mainly affects reproduced contrast, and the control called “contrast” is supposed to affect only brightness. The misleading labels have led to a great deal of confusion about how to set up a monitor for good reproduction.



This icon indicates the *Black Level* control, sometimes called *Brightness*. This control should be adjusted so that black picture content displays as true black on your monitor. Misadjustment of this control is the most common problem of poor quality picture reproduction on computer monitors, video monitors and television sets.



This icon indicates the *Picture* control, sometimes called *Contrast*. It affects the intensity that is reproduced for a full white input signal. Once *Black Level* is set correctly, *Picture* should be set for comfortable viewing brightness.

If you have a *bilevel* computer display that displays each pixel as either black or white but has no intermediate shades of gray, chances are that you have no *Black Level* control. If you do, it is either because you have an old-fashioned monitor, or because the same monitor could be used in a grayscale system.

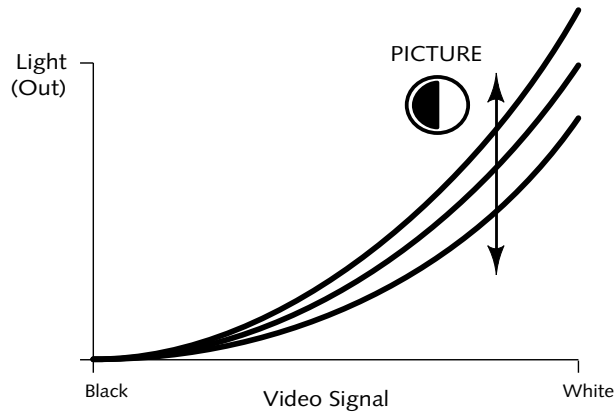


Figure 1 **Picture control** determines the light intensity produced for white, with intermediate values toward black being scaled appropriately. In a well-designed monitor, adjusting the *Picture* control maintains the correct black setting, indicated in this graph by the fact that zero input signal produces zero intensity at any setting.

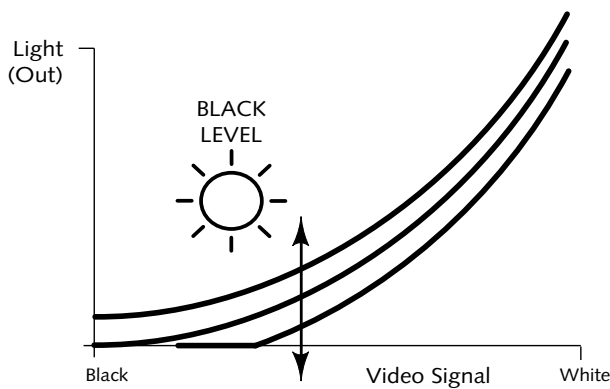


Figure 2 **Black Level** raises or lowers the entire curve with respect to light output. Although the intensity reproduced for any input signal is affected by the setting of the control, its most pronounced effect is at the lower end of the scale, near black. In electrical terms, black level controls the bias or offset of the video signal.

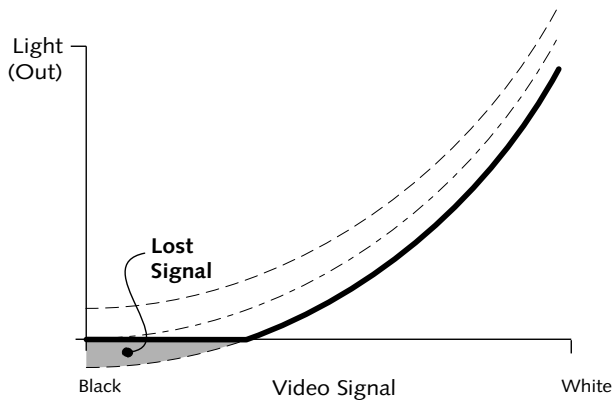


Figure 3 **Black Level set too low** causes a large range of input signals to be "crushed" or "swallowed." The control causes the electrical circuits to shift the whole curve, but when the signal gets to the display tube it cannot produce an intensity less than zero. The transfer function terminates abruptly at zero light level and a range of the input signal is lost.

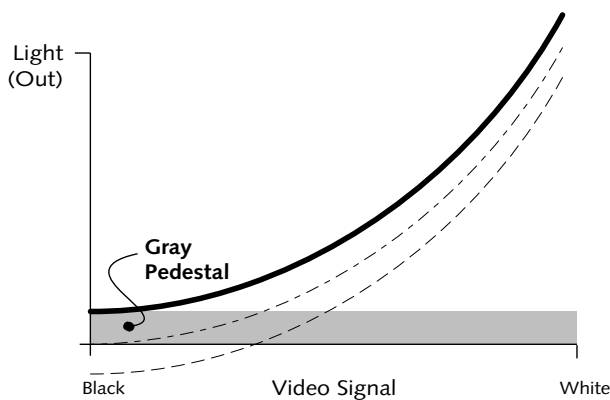


Figure 4 **Black Level set too high** means that no input signal can cause true black to be displayed: the picture content rides on an overall pedestal of gray, and the picture appears washed-out and faded. This misadjustment results in a loss of shadow detail and a generally muddy appearance of the picture.

I will explain the controls with reference to Figures 1 through 4 opposite. In the graphs, the X-axis represents the video signal input to a monitor and the Y-axis shows the intensity produced at the face of the screen. The transfer function involves a nonlinear relationship from signal to light.

Contrast ratio is the ratio of light intensity between the brightest white that can be produced and the darkest black that can be produced. Contrast ratio is a major determinant of perceived picture quality: if a picture has high contrast ratio, you will judge it to be sharper than a picture with lower contrast ratio, even if the lower contrast picture has substantially more measurable resolution.

To achieve good reproduced contrast ratio and good picture quality, it is important to set black level accurately. The most common problem with picture reproduction on video and computer monitors is misadjustment of black level. Figure 2 shows what happens if *Black Level* is set too low. Figure 3 shows what happens if *Black Level* is set too high.

Monitor Adjustment

It may be that *Picture* is the only control on your monitor's front panel! In all but the most demanding viewing conditions, *Black Level* should not require user adjustment. If you have no *Black Level* control, simply adjust *Picture* to the intensity you prefer for the brightest (white) areas of the picture and you are finished with monitor adjustment – the remainder of this note does not apply to you! But if you have a *Black Level* control, you should adjust it in accordance with the remainder of this note.

If you have no front-panel *Black Level* control, but suspect that your monitor is not reproducing black correctly, there may be a back-panel control that you can adjust. Otherwise, you should request that a service technician make the necessary calibration.

A monitor is properly adjusted when it meets two conditions. First, a black input signal should produce true black, to maximize the contrast ratio of the display. Second, a white input signal should produce the desired intensity.

The easiest way to adjust a monitor is to perform the following three steps in sequence: (1) turn the *Picture* control to minimum and display a black picture, (2) adjust the *Black Level* control to reproduce black correctly, then (3) adjust the *Picture* control to display the brightness level that you desire.

On a monitor or television receiver with the old names for the controls, first adjust the *Brightness* control to obtain a true black that will maximize *contrast*, then adjust the *Contrast* control for the appropriate *brightness*. You can now understand why the modern names for these controls are *Black Level* and *Picture*, and why it's sensible to use icons

instead of names to identify these controls. Unfortunately, the old television-style names have been inherited by modern devices such as scanners and image editing programs, so you may have to remember that their functions are opposite to their names.

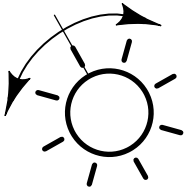
Step 1: Display Black



The first step in monitor adjustment is to set *Picture* to its minimum limit. In a well designed monitor, this setting will cause the visible raster to disappear. If your monitor's picture cannot be made to vanish, then you will have to arrange to display a picture that is mostly black, perhaps by using a screen-saver.

Television stations and networks fade to black between commercials. If you are adjusting a television receiver, you can use this "black" to set black level. So-called "smart" television sets have automatic black level circuits that alter black level as a function of picture content. These circuits should be defeated if possible, for the sake of both monitor adjustment and high-quality viewing.

Step 2: Adjust Black Level

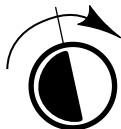


The second step in monitor adjustment is to adjust the *Black Level* control to the balance point or threshold, low enough that a black area of the picture emits no light, but high enough that setting the control any higher would cause the area to become a dark gray.

Computer monitors are generally *underscanned*: the extreme margins of the screen have no picture content. A rough setting for black level can be found by making the underscanned margins as black as possible. However if your framebuffer has *nonzero setup* (or *EIA-343-A levels*) then this method is inaccurate. Using black picture content, instead of the margins, always assures an accurate setting.

If lifting the *Black Level* control slightly above its threshold setting results in a dark color instead of a dark gray, your monitor is *mistracking*: the internal *cutoff* calibration of one or two of its guns is set incorrectly. A serviceman can repair this problem.

Step 3: Adjust Picture



Once black level is set correctly, *Picture* can be adjusted so that a white signal produces the appropriate level of intensity. In a television studio environment there are standards for absolute intensity. Outside that environment there is no "proper" setting of this control; it depends entirely on your preference.

Resist the temptation to set your monitor too bright. Excessive brightness has a number of disadvantages. First, your sensitivity to flicker increases as brightness increases, so setting your monitor too bright is likely to increase your perception of flicker. Second, a number of phenomena act to scatter light onto the face of the screen, and the higher the brightness of bright areas of the picture, the more light is

scattered into the dark areas. This scattered light reduces the contrast ratio – hence the perceived quality – of the picture. Third, operation at high brightness tends to defocus the electron beam of the CRT, resulting in poor sharpness.

Some poorly designed monitors exhibit variation in black level upon adjustment of *Picture*. If your monitor suffers from interaction, after adjusting *Picture* you may have to go back and tweak *Black Level*. It may even be necessary to iterate between the two controls a few times in order to set the combination that both reproduces black correctly and reproduces white at the brightness you desire.

A studio video *color bar* signal includes a *picture line-up generator* (PLUGE) element at the bottom of the screen, which comprises a reference black bar with two small variations: an excursion slightly blacker than black, and an excursion slightly lighter than black. *Brightness* is correctly set when the blacker-than-black element is indistinguishable from black, but the lighter-than-black element is just barely visible.

Further Reading

Charles A. Poynton, "Gamma and Its Disguises" in *Journal of the Society of Motion Picture and Television Engineers*, Vol. 102, No. 12 (Dec. 1993), 1099–1108.

For details of the nonlinear transfer function ("gamma") of a video monitor, see my *Gamma FAQ* available on the Internet at <http://www.inforamp.net/~poynton/>.

For even more detail, consult my SMPTE article.