LUMINANCE CLAMPING

If you're editing DV footage using a Firewire system, there's a chance that the DV CODEC your system uses might be screwing up your color. Some older editing programs, such as Apple's Final Cut Pro 1.2 have a luminance clamping problem. Though this is not as big an issue as it was a few years ago, if you're finding that the highlights in your image are blown-out, or too hot, you might be facing a luminance clamping problem.

To understand why (and what you can do about it), you need to understand how digital video handles the luminance – or brightness – information in a video signal.

As we discussed in the *Digital Filmmaking Handbook*, video signals contain luminance information and chrominance, or color, information. With these two pieces of data–what color something is, and how bright that color is–your video monitor can recreate an image. Luminance is measured using a scale called IRE, where white is 100 IRE (or 100%) and black is 7.5 IRE (or 7.5%). Remember, though, 100 IRE is simply the value of white, and is not necessarily the brightest color that can be displayed. Your camera, whether DV or analog, is capable of shooting colors that are brighter than 100 IRE, and you'll see these areas as bright highlights and "hot" spots.

When a video signal is digitized, the luminance of each pixel is assigned a numeric value between 1 and 254. Black is defined as 16, and white is defined as 235. By putting white at 235, rather than 254, the digital luminance scale has enough "headroom" for the areas of your image that are brighter than white.

Unfortunately, your computer uses a slightly different measure of luminance. On your computer screen, black is represented by 0, while white is represented by 255. In trying to reconcile these two different systems, your DV CODEC runs into some problems.

For example, some DV CODECs will scale the black in a video signal from 16 down to 0, and the white from 235 up to 255. The values in between will be scaled accordingly. The problem with this approach is that all of that headroom above 235 gets clipped off, or clamped. So, highlight areas of your image that normally appear as a range of whites will get reduced to flat blotches of white (see Figure 1 on the next page).

However, if your DV CODEC leaves the white and black values alone, then you run into another problem. Because your computer uses different standards for black and white, video with black and white values of 16 and 235 will appear less contrasty on your computer screen. Whites will appear slightly gray, rather than white. In addition, any graphics you've created on the computer will have "illegal" blacks and whites (since they'll be using the computer's measures of black and white) and will have more or less contrast than your digital video.

Figure 1. In these two adjacent frames, the left image is unclamped, while the image on the right has been clamped.

So what's a DV filmmaker to do? That depends largely on which CODEC you are using and what type of editing and effects you are creating. First, you need to decide if your CODEC performs luminance clamping (sometimes referred to as luminance scaling).

- **Apple DV** The Apple DV CODEC that's built-in to QuickTime 4 clamps luminance and, unfortunately, there's no option to make it do otherwise. In addition, the QuickTime CODEC performs a slight adjustment to the midtones (or gamma) to darken DV images so that they'll appear better on your computer screen. (You can undo Apple's automatic gamma correction by applying a Levels filter to your footage. Use a gamma setting of about 1.2. If you later want to undo this correction, apply a Levels filter with a gamma of around .84.)
- Digital Origin DV The DV CODEC that ships with DigitalOrigin's EditDV and MotoDV products provides an option for deactivating luma clamping. Selecting SoftDV On prevents the CODEC from scaling luminance, while SoftDV Off activates luminance scaling. The Windows version of the CODEC also lets you alter the black point of an incoming clip, and provides separate controls for compressing and decompressing.

No matter how your CODEC handles luminance, you'll be safest if you simply try to avoid illegal hot spots when shooting (that is, keep from shooting with values over 100 IRE). This is fairly simple if your camera has a zebra feature, as the zebra display will show you over-exposed areas of an image. You can then iris or shutter down to control them.

If your camera doesn't have a zebra feature, your next best option is to take a good field-monitor to your shoot. If you calibrate the monitor with standard color bars, and keep tabs on your footage while you shoot (or better yet, use the monitor as your viewfinder), you can do a good job of controlling hot spots. If you really want to get picky, you could even take a scope with you and monitor your signals to look for illegal color.

If you don't have a monitor, or your shoot precludes using one, then spend some time before you shoot learning to recognize hot spots in your camera's viewfinder. Connect your camera to a monitor and pay attention to how images in the viewfinder compare to images on the monitor.

There will be times, though, when you can't avoid illegal luminance. Perhaps you can't avoid a harsh backlight and decide to over-expose your background to be able to see the foreground. Or maybe you're choosing to over-expose part of your image for stylistic reasons. In these instances, you'll be much better off working with a CODEC that allows you to use the full, rather than scaled, range of luminance. Such a CODEC will keep your over-exposed areas from turning into blobby areas of white.

If your production involves a lot of computer-generated images or graphics, you'll need to give some additional thought to your luma options. Because your computer-generated imagery (CGI) will use values of 0 and 255 for black and white, respectively, using scaled luminance will result in better composites since your CGI elements will have a contrast range that's more in line with your video.

Tip: IRE, It's the Law

An F.C.C. law, to be exact. If your project is ultimately destined for broadcast, you'll need to be particularly careful about keeping your color and luminance values within the legal limit. Most broadcasters will not accept video with signals that go beyond the legal NTSC limits.

MANUAL ADJUSTMENT OF LUMINANCE

No matter how careful you are when shooting, there's always a chance that you'll have video with blown-out whites that don't respond well to luminance clamping. In these instances, you may want to try manually clamping the luminance. For this to work, you'll need a CODEC that allows you to deactivate luminance clamping.

Using a program like After Effects, apply a Curves filter to the offending clip and set the black point at 0. However, rather than cut off the whites at 235 (the way a luma clamping CODEC will), create a curve that will slowly roll off the whites. This will keep your hot spots from turning into a solid mass of white. Note that this will change the contrast in your image, but altered contrast will probably be better than flat, solid highlights. And, your highlights will now be legal for broadcast (Figure 2). Remember to reactivate the clamping in your CODEC before you continue.

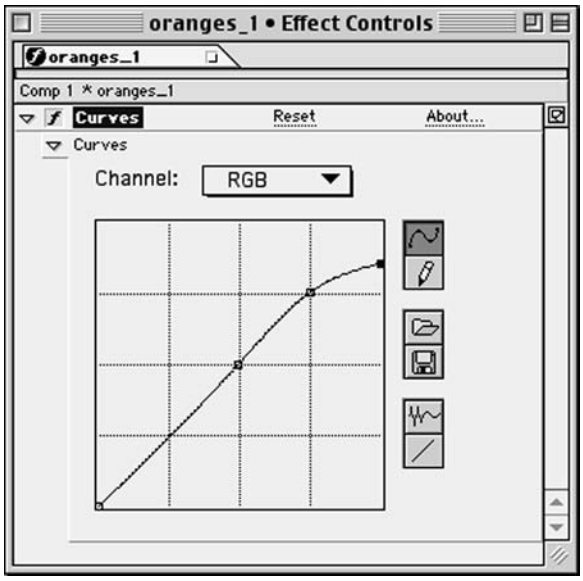

Figure 2. With a simple Curves adjustment, you can manually "roll off" bright spots rather than clamping them.

LUMA CLAMPING TROUBLES

If you are using a CODEC that clamps luminance, you face another problem besides having your highlights reduced to flat blobs of white. Say you have a four second clip and you need to crop the frame to a smaller size during the last two seconds. The easiest way to do this would be to make a cut in the clip at the 2 second mark, and then apply a crop filter to the second part of the clip.

This cropping will cause your NLE to render new pixels for that clip, which of course, will require recompression using your chosen CODEC. Unfortunately, if your CODEC performs luma clamping, the second clip will now have very different luminance values than the first clip. Because the two clips are butted against each other, this change in luminance will be very obvious, and quite distracting.

What can you do? The best choice is to find a CODEC that lets you render unclamped video. If this is not an option (either due to cost or availability) then you need to get the computer to re-render both clips (and possibly your entire movie) so that every clip will be subject to the same clamping. If you apply a one-pixel crop to each clip, then the computer will be forced to re-render everything. Because your video is overscanned, you'll never see this 1-pixel loss.

This document is a companion to the Digital Filmmaking Handbook, 2nd edition, by Ben Long and Sonja Schenk, published by Charles River Media (www.charlesriver.com).