FiLMiCPRO

FiLMiC Log - Technical White Paper

rev 1 - current as of FiLMiC Pro iOS v6.0

FiLMiCInc

Note

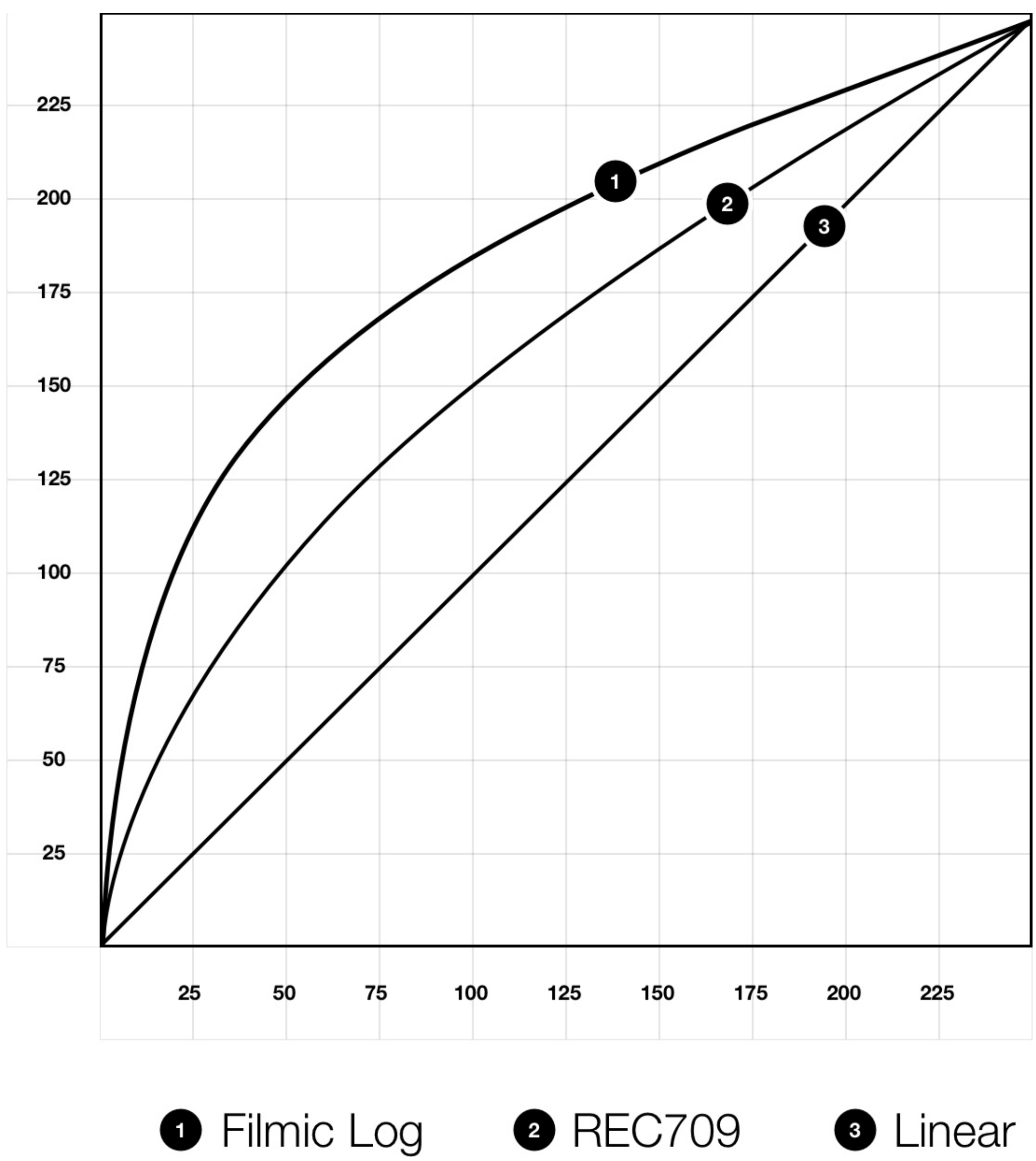
(FiLMiC Log is patent pending intellectual property of FiLMiC Inc.)

Abstract

Filmic Log is a gamma function that protectively remaps linear (or linearized) raw image data buffers, enabling greater flexibility when grading footage in post-production.

What is the purpose of a logarithmic remapper for low-bit-depth video? If there is an intention to correct or modify mobile-originated footage in post production, the raw data must be reorganized protectively before encoding. When footage is exposed properly, Filmic Log can preserve almost the entire tonal range of the raw buffer in the encoded medium.

Filmic log is a composite curve whose spline is heavily influenced by a base-10 logarithmic function. Unlike most “flat” gamma profiles, Filmic log does *not* exhibit an exaggerated log shoulder.



Luma Characteristics

The filmic Log function has been designed to expose an additional stop in the encoded media without blackpoint/whitepoint modification. While Filmic Log is somewhat tolerant of underexposure, it is not designed to correct footage that was intentionally underexposed.

Control	2%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Filmic Log	2%	6.2%	17.5%	33.5%	45%	55%	63%	71%	79%	85%	92%	100%

Note that Filmic Log maintains natural looking gradation through the tonal range without inherent modification of the blackpoint or the whitepoint respectively. However, there are platform-specific controls in place that *will* crush basal gray if the dynamics of the video capture device do not support the remap.

sRGB

Filmic Log

The default configuration of Filmic Log does not remap luma as aggressively as other logarithmic solutions. An 8-bit color cube does not have enough data in its root sector to support an unmodified logarithmic remap without producing undesirable artifacts[1]. The Filmic Pro application compensates for this limitation by strictly maintaining the native blackpoint and whitepoint of the raw image buffer. However, whitepoint/midpoint/blackpoint adjustments are still possible by way of a separate remapping tool in the Filmic Pro application interface. Any adjustments that the user makes to whitepoint/midpoint/blackpoint is concatenated with the log remapper into a single fragment shader and executed at runtime in a 10 bit container[2]. The user is then able to determine how much the basal dynamics of a scene are to be modified. With minor blackpoint and midpoint adjustments, it is generally possible to capture the *entire* available dynamic range of the image buffer in the encoded media.

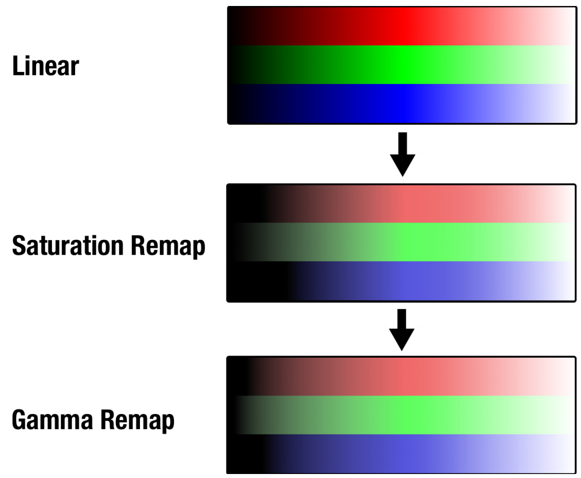
[1] Artifacts include striping, chroma noise, and sparse-data noise

[2] This approach alleviates the need for destructive intermediate renders; Math is done in an 10 bit container, but the output is still 8 bit

Chroma Characteristics

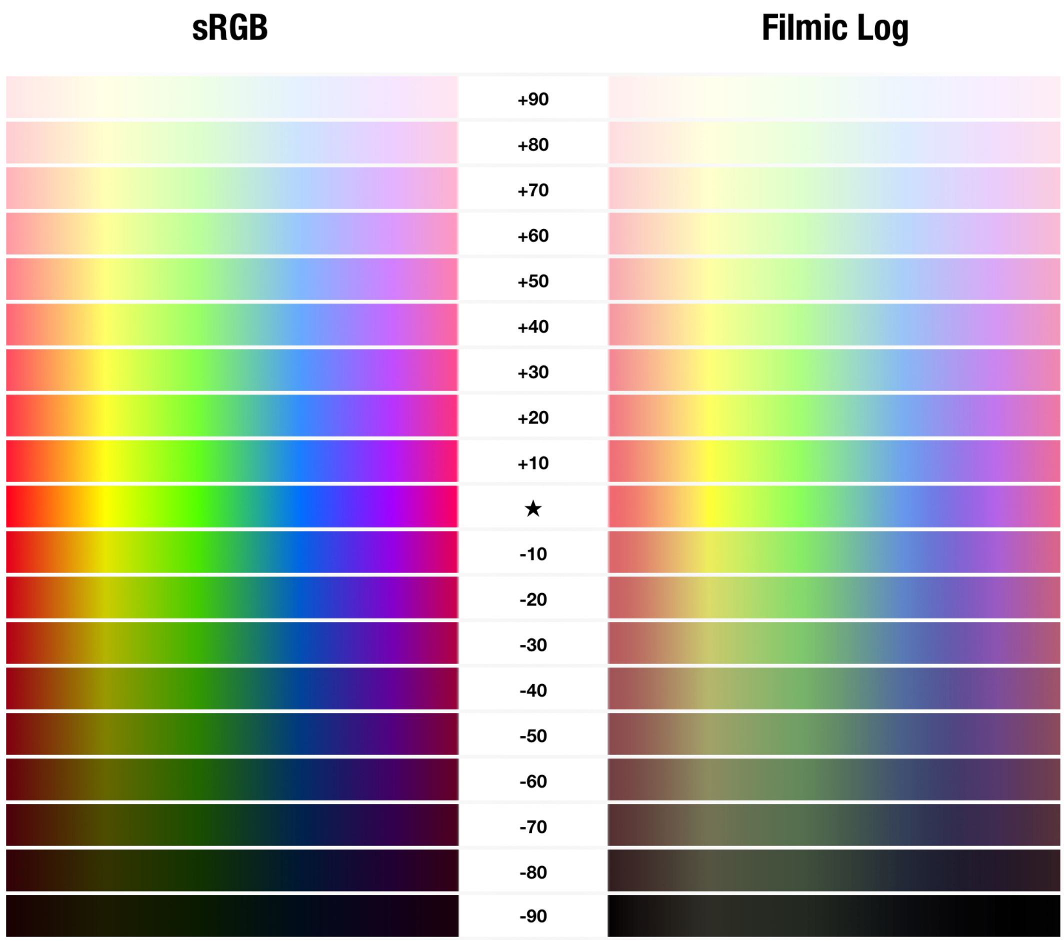
The Filmic Log pipeline remaps the chrominance of the linear image-buffer *before* the gamma remap takes place. A Chromatic conditioning stage is employed to achieve three objectives:

1. Better emulation of the spectral sensitivity of color-negative film
2. Protection against hue shifts consequent of gamma adjustment
3. Minimization of chroma noise in critically underexposed regions of the image buffer



The chrominance remap is accomplished with a logarithmic colorimetric (relative luminance) weight[3]. While the saturation remap itself is logarithmic, it has a markedly different spline than the subsequent gamma remap.

The saturation remap will increasingly desaturate the color as it approaches basal gray. Of particular note, the Red, Green, and Blue channels are remapped separately with distinct weights. The **red channel** desaturates at 9.333% IRE; the **green channel** desaturates at 4.888%; the **blue channel** desaturates at 20.222%.



While this technique effectively controls chroma noise in critically underexposed regions of the image buffer, blue-channel dominant colors may be rendered with a gray cast when dramatically underexposed.

Even though gamma and saturation are remapped separately, Filmic Log introduces no discernible hue shifts above 15 IRE - below which, saturation simply decays along a logarithmic spline.

[3]All remapping is done in an intermediate RGB colorspace

Gamma Remap Function

Using a fragment shader or a kernel, the gamma of the conditioned linear bitmap is conformed to the Filmic Log spline. This remap is done in a 10 bit container and performed on a per-pixel basis.

The formula representing the Filmic Log curve is as follows:

$$\mathbf{y} = 0.371 \times (\mathrm{sqrt}(\mathbf{t}) + 0.28257 \times \ln(\mathbf{t}) + 1.69542)$$

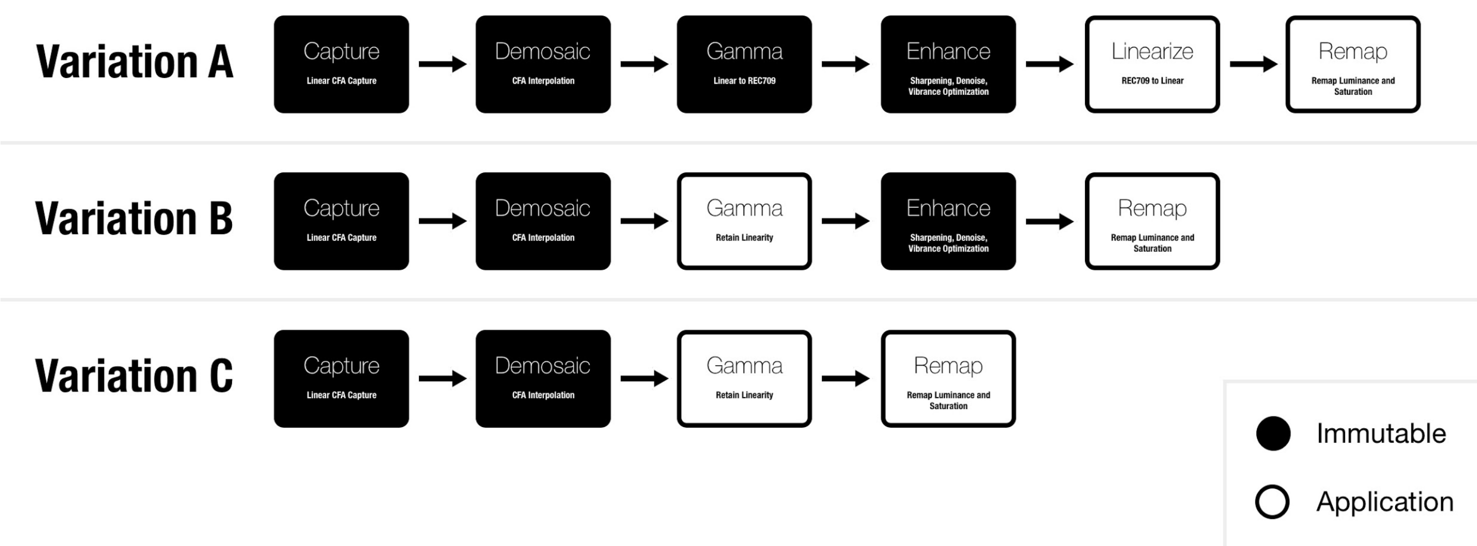
Where both **y** and **t** are scalars operating within a range of 0.0-1.0 representing a percentage correlative to values in the intermediate color space.

Shader Based Approach

Filmic Log is was designed to be implemented with a GPU shader. Lookup tables require data point interpolation and can result in unsatisfactory tonal gradation. As a consequence, Filmic Log is computationally intensive.

Pre-encode Capture Pipeline

Three platform-specific capture pipeline variations are employed to ensure optimal buffer conditioning and remapping before encoding.



Minimizing Noise

To make filming at a base ISO range more practical, Filmic Log has been designed to be somewhat *tolerant* of underexposure. Filmic Log can safely remap footage that is underexposed by -0.75 EV on a reasonable gamut of recently manufactured mobile devices[4]. Devices with ⅓” class CMOS sensors[5] typically have lower basal ISO’s than camera’s with larger dies. On these devices, it is not only acceptable to shoot at a basal ISO, but it is *preferable* for two reasons:

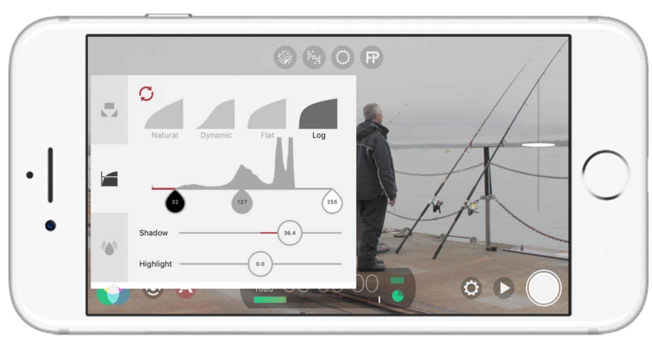
Destructive Noise Reduction

Devices with ⅓” class camera modules tend to produce chrominance noise at relatively low ISOs. Depending on the device, ISO levels as low as 200[6] may automatically activate a **spatial** or **composite** noise reduction pipeline. Spatial noise reduction is undesirable because filamentous details (hair, grass, string), delicate textures (skin, fabric, paper), and color accuracy will irreparably degrade. Alternatively, multi-frame composite noise reduction can result in motion artifacts that cannot easily be repaired in post production. Filmic log is typically applied *after* noise reduction if NR it is an immutable fixture of the device’s capture pipeline; it is therefore best practice to keep ISO levels as low as practical to minimize the impact of on-device NR.

Channel Divergent Noise

In a Bayer configuration, Red, Green, and Blue filtered photodiodes will manifest signal quality variance at the same level of amplification. The green channel usually exhibits the least noise, followed by the red and blue channels respectively. While this is true of all CCD and CMOS photosensors, the smaller sensors found in mobile phones and tablets tend to express this phenomenon more acutely - with the blue channel in particular falling off quite rapidly. By way of example, an image with a noisier blue channel (captured at a medium-high ISO) may produce skin tones that look unnatural even if chroma noise is superficially moderate. To minimize chroma noise in underexposed regions of the buffer, Filmic Log employs a perceptual-luminance weighted saturation remap that progressively reduces the saturation of critically underexposed pixels. However, this will not repair color shifts that are a byproduct of moderate/high ISO capture. The best practice is to shoot near a basal ISO to ensure accurate color rendering.

Maximizing dynamic range



Some newer full-frame CMOS sensors offer dynamic range that varies with ISO in a bell shaped curve, peaking well past the base ISO. This is ***not*** a characteristic of most mobile camera modules. With *mobile* sensors, dynamic range peaks at (or very near) base ISO and falls off rapidly from there. Be advised that the total dynamic range of the sensor will be much less than a dedicated still or video camera[7]. While Filmic

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[4] Verified on iPhone 7 & 6S series, Google Pixel, and Galaxy S7

[5] Some exotic mobile camera modules are manufactured with much smaller (or larger) sensors, however Filmic Log has been specifically designed to remap images produced by ⅓” class dies

[6] Noise reduction ISO threshold is variable based on device capability, software environment, and manufacturer specification

[7] At the time of this writing, the camera modules in high-end, mainstream mobile phones can capture no more than 10 stops of usable dynamic range without the aid of multi-sample compositing.

log has been designed to *maximize* the available dynamic range of the image buffer, it cannot *add* dynamic range that is not there. To facilitate higher latitude capture, Filmic Log can be *safely* underexposed by -0.75 EV, it is *tolerant* of -1.5 EV underexposure and +1.25 EV overexposure.

Low Dynamic Range Shooting

To maximize total dynamic range in a low dynamic range scene, metering indirect ambient light against an %18 reflectance gray card is appropriate. Slight underexposure may be required to protect highlights.

Medium Dynamic Range Shooting

In a medium dynamic range scene, at least a portion of the composition will need to be moderately underexposed. In this case, meter for the highlights[8]. In compositions where the requisite under-exposure has resulted in nearly crushed blacks, the black point should be raised *slightly*. If this does not recover enough information in the shadows, a shadow boost may be employed. However, use the shadow boost tool sparingly as it can result in unwanted hue shifts and gradation changes.

High Dynamic Range Shooting

In a high dynamic range scene use a spot meter to determine if the total dynamic range of the environment exceeds 9-10 stops. If the scene does *not* exceed that gamut, consider raising the black point slightly and use Filmic Pro's luminosity map overlay to optimize the midtone/highlight ballance.

If there are greater than 10 stops of dynamic range in the scene, some environmental controls will be required to effectively shoot on a mobile platform:

Indoor Setting

If windows or television screens, are present, neutral density film will be required. If a character is using an electronic device with a screen, turn down the brightness. If there is a lighting fixture in the scene, replace the bulb with a low-lumen equivalent. Only after the brightest light sources are moderated, should the global ambient lighting of the scene be evaluated.

Outdoor Setting

For static scenes, a graduated neutral density filter may be required to compensate for the brightness of the sky. Evaluate artificial light sources and external windows, applying the same methodologies to them that you would when shooting indoors.

[8] Alternatively, you may meter skin tones if a fair-complected subject in in the composition