



# Canon 709 & CMT 709 White Paper

## Technical Information

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## Canon 709 & CMT 709 White Paper

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# 1. Overview

## 1.1 Development Background

Canon has released a wide lineup of video production cameras, including the **Cinema EOS** line of digital cinema cameras and the **X Series** of professional camcorders. These cameras have been designed for video production by supporting post-production workflows and feature Log gamma curves such as Canon Log 2 and Canon Log 3. These gamma curves make it possible to produce more natural images with a wide dynamic range. Helping simplify the post-production process, the cameras also offer finished looks such as the BT.709 Wide DR for video that can be handled without the need for extensive post-production.

To further assist this process, Canon now introduces two new looks for the BT.709 color space: **CMT 709** and **Canon 709**. These new looks are specially designed to preserve highlights for later color grading and deliver great results straight out of the camera. They will be rolled out to multiple Canon models starting with the October 2022 firmware updates for the EOS C500 Mark II and EOS C300 Mark III.

## 1.2 Two Looks for Different Uses

The **CMT 709** look is available as a LUT for converting Canon Log 2 or Canon Log 3 images to provide a more optimal look for monitoring scenes shot in RAW format or using a Log gamma curve, or as a starting point for color grading.

Use of the CMT 709 look for monitoring when shooting in Canon Log 2 or Canon Log 3 offers an optimal monitoring experience. This is because CMT 709 makes it possible to check the entire wide dynamic range of the Log gamma curve while maintaining contrast and saturation that are easy to see on an SDR monitor.

For color grading in post-production, the CMT 709 look can be used as a great starting point as it was designed to keep the Log gamma curve's characteristics and allow simple, straightforward look adjustments.

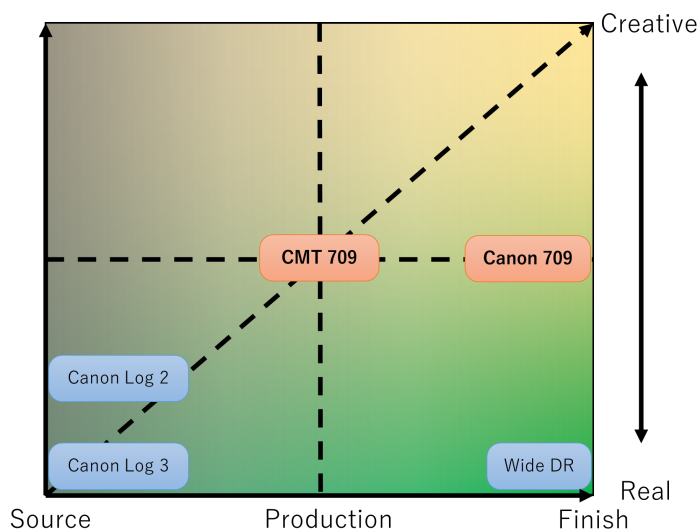
On the other hand, the **Canon 709** look is Canon's own recipe to help deliver content with minimal post-production, and produce footage that can be used as the final image straight out of the camera. Compared to the BT.709 Wide DR look, the contrast and color were enhanced

for a richer overall look based on Canon’s interpretation of optimal sensor output and visually pleasing color data. The Canon 709 look was formulated by prioritizing the expression of skin tones as the most important consideration. The look faithfully reproduces subtle changes in skin color. The overall natural color reproduction builds upon Canon’s long-standing color science and is intended for use capturing any subject and any scene. Canon 709 was designed to produce film-like visual characteristics for productions with fast turnaround demands, that cannot spare the time for post-production, such as TV broadcasts, short-form video content or wedding and event videography. The Canon 709 color space still captures a wide dynamic range, leaving room for the option of further color grading.

This look is included as a Custom Picture option, making it possible to create richly finished video content without the need for intricate color grading.

### 1.3 Positioning of the Looks

Figure 1 shows the positioning of the new looks. The horizontal axis represents the content creation process: the further to the right, the closer the recorded video is to the finished image. The vertical axis represents the look’s level of processing: more realistic looks are placed lower while looks that give the impression of a higher degree of processing are placed higher.



**Figure 1 Positioning of Various Looks**

Canon has been offering the BT. 709 Wide DR look to produce the video look that is typical to content used in traditional news programs.

The CMT 709 look is intended to be a start-point look for creative color grading that can be used as intermediate material in the production process. CMT 709 is intended to offer professionals a better starting point when shooting Log and allows for color grading that enhances visual aspects beyond their standard appearance, or minimizes these characteristics so as to more accurately represent a real-world look. Additionally, based on the BT.709 color space, the CMT 709 is a useful and time-saving option for on-set monitoring.

This white paper describes the Canon 709 look for footage that can be used as the finished work and the CMT 709 look for on-set monitoring and as a starting point for color grading.

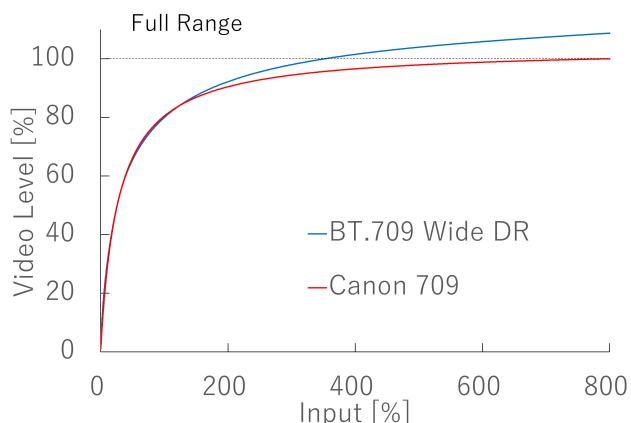
## 2. Characteristics – Canon 709

### 2.1 Canon 709 General Characteristics

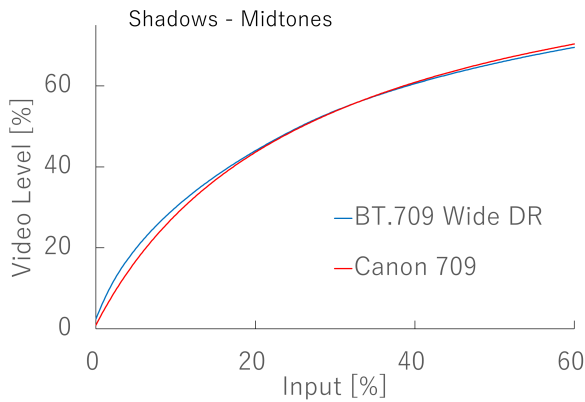
The Canon 709 look has a film-like look overall, with black tightened to increase contrast in the midtones for a clearer impression. It has a wide dynamic range and natural color reproduction, giving it a look that makes it possible to use the recorded video as the final image without any color grading work. It is also highly suitable for editing and distribution, as it makes it possible to convey the image as it was shot.

### 2.2 Canon 709 Tone Curves

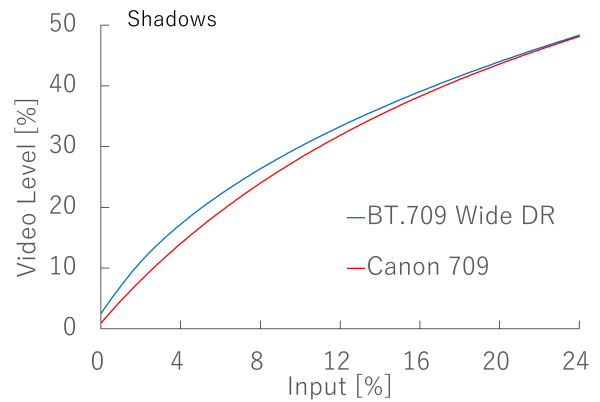
Figures 2 to 4 compare the tone curves of the Canon 709 look and the BT.709 Wide DR look that has been included in the Custom Picture until now.



**Figure 2 Canon 709  
Tone Curve (Full Range)**



**Figure 3**  
**Canon 709 Tone Curve**  
**(Shadows to Midtones Area)**



**Figure 4**  
**Canon 709 Tone Curve**  
**(Shadows Area)**

In the BT.709 Wide DR look, the black level was set at roughly 2.5%, but in the Canon 709 look, the black level is set at roughly 0.9%. The characteristics of the darkest area near total black were also reviewed. The contrast close to total black was reduced to make noise in the dark areas less noticeable, and the contrast in the low-to-mid-brightness regions was enhanced to create a clearer impression. The contrast in the highlights was gently reduced and the dynamic range was kept at 800% (720% reflectivity), creating a soft expression while preserving detail. Additionally, as we considered the expression of skin tones to be of the utmost importance, we built upon our achievements with the BT.709 Wide DR look, to produce smooth skin tones while making facial features look solid and defined.

Table 1 shows the output values for the reference input. The code value is the output value for a 10-bit video range signal. Proper exposure when shooting middle gray (18% gray) is almost equivalent to that of the BT. 709 Wide DR look, so users accustomed to shooting with the existing looks can seamlessly start using the new look. Note that the values in the table are theoretical and may differ slightly due to in-camera processing.

<b>Input Luminance (Reflection)</b>	<b>0% (0% black)</b>	<b>20% (18% gray)</b>	<b>100% (90% white)</b>	<b>800% (720%)</b>
Video Level	0.9%	43.6%	80.5%	100.0%
Code Value (10 bit)	72	446	769	940

**Table 1 Output Values for Basic Reference Inputs**

### 2.3 Canon 709 Color Reproduction

The Canon 709 look was designed with the expression of skin tones as the most important consideration, so it can faithfully reproduce subtle changes in skin color. The overall color reproduction builds upon Canon’s well-established natural color reproduction and can be used for any scene.

In addition, the overall color balance from the shadows through the highlights is tuned to give the impression of shooting with a traditional film camera following the characteristics of the tone curve. In the highlights, unnatural color shifts are suppressed to achieve a softer expression.

### 2.4 Canon 709 Super White

When capturing super white (signals exceeding 100% in the video range), some video systems (editing, distribution, etc.) may not be able to properly handle the look because it is different from the look used when monitoring at the shooting location, for example, if the super white part of the signal was cut off. For this reason, the Canon 709 look does not use the super white range, ensuring instead a wide dynamic range while keeping all information up to 100%. This makes it possible to handle data without loss when correcting the look using the Look File function of the Custom Picture or when making simple look adjustments in post-production. Also, even if the video is uploaded as is to video-sharing sites, it can be delivered with the same look as when it was shot with no signal loss.

## 3. Characteristics – CMT 709

### 13.1 CMT 709 General Characteristics

CMT stands for “Canon Monitor Transform” and, accordingly, the CMT 709 look is well suited for monitoring using the BT.709 color space. It covers the entire wide dynamic range of the Canon Log 2 gamma, making it possible to check the status of dark areas and highlights during on-set monitoring. Applying this look as a viewing LUT when shooting with Canon Log 2 or Canon Log 3, makes it easier not only to check the angle of view, adjust the focus, etc. but also to get a good idea of the finished image.

Additionally, the look’s image quality is designed to reduce contrast and saturation so it can support a wide range of creative image decisions in post-production. This makes it an easy look to use as a starting point for various color grading options.

### 3.2 CMT 709 Tone Curves

Figure 2 is a semi-logarithmic graph comparing the tone curves of the CMT 709 look with those of Canon Log 2 and Canon Log 3. The x-axis shows the number of stops relative to 18% gray.

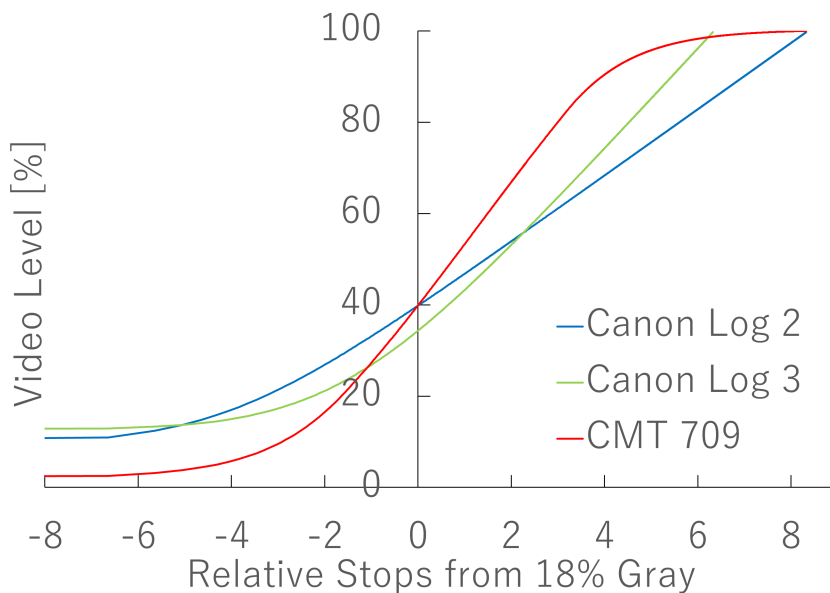


Figure 5 CMT 709 Tone Curve



The CMT 709 tone curve uses a more S-shaped contrast correction compared to the Canon Log 2's tone curve. It compresses the highlights to maintain a wide dynamic range and greatly increases the contrast in the midtones range.

The black level was significantly reduced compared to Canon Log 2 and Canon Log 3, but not all the way to total black (0%). Setting the black level at about 1.9% suppresses the clipping of the negative component of the noise and avoids the image looking as if black levels changed unnaturally. This also allows for more flexibility when adjusting the dark areas during color grading.

In the midtones range, the look keeps a wide section that appears as a straight line on the semi-log graph. This means that the tone curve has Log characteristics and, consequently, that brightness corrections during color grading are straightforward changes, making it possible to adjust the look as desired.

Highlights are greatly compressed to preserve the Canon Log 2's wide 6400% dynamic range. During on-set monitoring, it may seem that highlight detail is lost, but detail can be restored by raising the contrast while color grading. Note that the maximum dynamic range for Canon Log 2 in-camera recording or output is 1600% (as of 2023).

The look has a two-stop push development margin so that recordings can be used without the signal being clipped when RAW recordings are pushed during Canon Log 2 development or when Canon Log 2 recordings are push processed during color grading. Some detail corresponding to this margin can also be retained.

Table 1 shows the output values for the reference input. The code value is the output value for a 10-bit video range signal. Proper exposure when shooting middle gray (18% gray) is almost equivalent to that of Canon Log 2. This is intended to ensure the same 'feel' when setting the appropriate exposure level, even in a situation where users switch between monitoring the Canon Log 2 image as is, without applying a LUT, and monitoring with a LUT that converts the image to CMT 709.

Note that the values in the table are theoretical and may differ slightly due to factors such as the LUT interpolation process

<b>Input Luminance (Reflection)</b>	<b>0% (0% black)</b>	<b>20% (18% gray)</b>	<b>100% (90% white)</b>	<b>1600% (1440%)</b>	<b>6400% (5760%)</b>
Video Level	1.9%	39.9%	71.2%	98.7%	100.0%
Code Value (10 bit)	81	413	688	929	940

**Table 2 Output Values for Basic Reference Inputs**

### 3.3 CMT 709 Color Reproduction

The CMT 709 look was designed with the expression of skin tones as the most important consideration, so it can faithfully reproduce subtle changes in skin color. Moreover, users can express skin textures more richly through color grading adjustments. The overall color reproduction builds upon Canon’s well-established natural color reproduction and can be used for any scene. Additionally, the saturation is reduced to leave room for color grading.

### 3.4 CMT 709 Super White

When using super white (signals exceeding 100% in the video range), some video systems (editing, distribution, etc.) may not be able to properly handle the look because it is different from the look used when monitoring at the shooting location, for example, if the super white part of the signal was cut off. For this reason, the CMT 709 look does not use the super white range, ensuring instead a wide dynamic range while keeping all information up to 100%. As a result, the look of the image monitored on the shooting set is the same as the look of the image after the LUT is applied in post-production, making it possible to perform color grading on an image that gives the same impression as the image reviewed on-set.

## 4. Application on the Camera

The Canon 709 look can be selected under the [Gamma/Color Space] setting in the Custom Picture file.

The [Color Matrix] setting allows users to change the color reproduction balance, but [Neutral] is the recommended option for the Canon 709 look. Users can also apply additional Custom Picture image quality functions (except [Black Gamma], [Knee], and [Over 100%]), allowing in-camera tweaks to achieve the desired look.

These settings apply to all recordings and output devices, including in-camera recordings, LCD screen display, SDI/HDMI outputs, and Browser Remote.

The CMT 709 look is provided as a LUT that can be applied to the output signal (SDI, HDMI, etc.) or to the image displayed on the LCD screen or a viewfinder. This LUT can be applied when the [Gamma/Color Space] setting in the Custom Picture file is set to [Canon Log 2 / C.Gamut] or [Canon Log 3 / C.Gamut]. The LUT can be turned on and off independently on each output/monitoring device. This can be done from the menu, but using an assignable button, users can switch back and forth with a single press of a button.

Note that when the SDI or HDMI output is converted to CMT 709 using a LUT, the output signal is automatically converted to Narrow Range (Video Range). If the Log image was being output as Full Range, users should pay attention to the change in the signal's range.

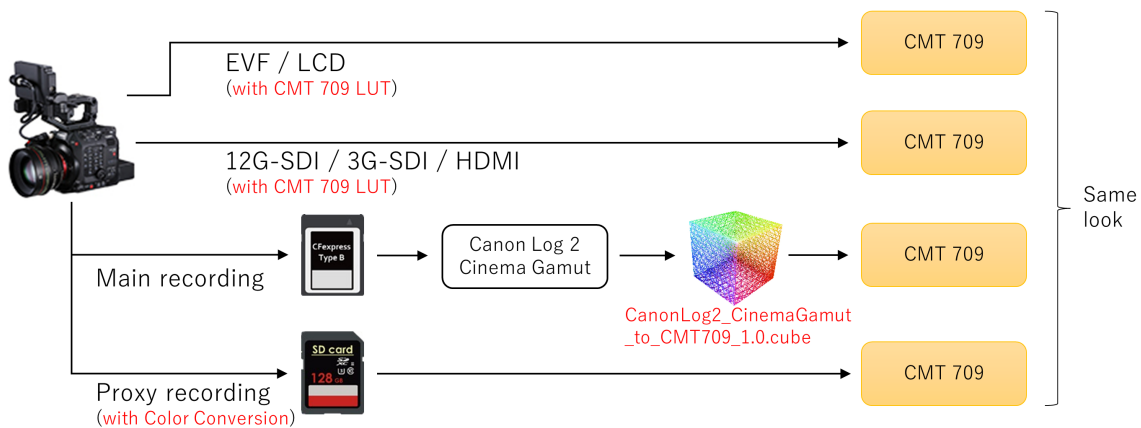
Canon plans to offer the LUT that converts the image to the CMT 709 look on all cinema and video production cameras. However, even before it is offered as a menu option, users can register and apply the LUT file on camera models that offer the User LUT function. The LUT files for conversion from Canon Log 2/Cinema Gamut or Canon Log 3/Cinema Gamut to CMT 709 can be downloaded from the official Canon website.

Depending on the camera model, the LUT cannot be applied to some video outputs. On camera models that offer the View Assistance function instead of LUTs, the process involves a simplified conversion. It is also possible to convert proxy recordings to the CMT 709 look. However, this also involves a simplified conversion.

## 5. Workflow

### 5.1 CMT 709 Overall Workflow

Figure 3 shows an example of a workflow that uses CMT 709. In a typical RAW or Log shooting workflow, the CMT 709 look can be used for on-set monitoring, as the look for dailies and as a basis for color grading. The image monitored at the shooting location, the images recorded as proxy files, and the recordings used for color grading will all have the same look, avoiding any discrepancies in the perception of the look between the teams at the shooting site and in post-production.



**Figure 6 A Workflow Example**

After applying the CMT 709 look while shooting, if it is difficult to check the darkest areas near total black or the detail in the highlights of a scene, users can temporarily turn off the LUT to better appreciate the details.

Proxy recordings are converted to the CMT 709 look using only a simplified color conversion. They can be used for cut editing without any problem. However, if proxy files are to be used for color grading, users should apply a LUT that converts to CMT 709 in post-production.

## 5.2 CMT 709 Post-Production

It is much easier to create BT.709 content by applying the CMT 709 conversion LUT to recordings developed from RAW clips using a Log curve, or to Log recordings, than by color grading material in the original Log state. The conversion can be applied as either an Input LUT or an Output LUT, so users can choose according to their color grading style. The recommendation is to apply the conversion as an Output LUT, as it makes it easier to create the desired look taking advantage of the faithful response of the Log space and the Cinema Gamut's wide color space. Even when the conversion is applied as an Input LUT, the LUT keeps the Log characteristics over a wide range and maps to the BT.709 color space so that highlights and high-saturation colors are not clipped. This allows for more flexible processing than when color grading in a typical BT.709 color space.