LEICA L-LOG
REFERENCE MANUAL

Contents

1 Document Version History 03
2 Purpose of This Document 03
3 L-Log Curve Characteristics 03
3.1 LSR-to-L-Log Conversion 04
3.2 L-Log-to-LSR Conversion 05
3.3 Mapping of LSR to IRE, DV and EV 05
4 Colorimetric Characteristics 07
4.1 Colorimetric Conversions 08
5 Camera Settings for Recording L-Log 08
6 Recording L-Log Externally 08
7 Exposing L-Log 09
7.1 Exposing for Easiest LUT Application 09
7.2 Exposing for Best Image Quality 10
8 Editing L-Log Footage 11
9 Explanation on Higher ISO Value in L-Log 12

List of Figures

1 Extended L-Log Curve 03
2 L-Log Curve 04
3 Relationship Between EV and 10 Bit DV 06
4 Relationship Between EV and 12 Bit DV 06
5 Comparison of Color Spaces 07
6 Gray Card Scene 09
7 LUT Applied Without Correction 10
8 LUT Applied Before Correction 10
9 LUT Applied After Correction 10
10 Levels Interpretation Comparison 11
11 Tone Curve Comparison 12

List of Tables

1 LSR Mapped to IRE, DV and EV 05
2 L-Log Clipping Values 05
3 L-Log Color Space Properties 07

1 Document Version History

Version	Date	Comment
1.0	January 11, 2021	Initial revision
1.1	May 5, 2022	12 bit and RAW video info added; clipping values added; general improvements
1.2	October 28, 2022	Info on L-Log exposure added
1.3	February 8, 2023	Hint regarding levels interpretation added
1.4	September 14, 2023	Q3 data and explanation on higher ISO value in L-Log added
1.5	January 22, 2024	SL3 data added

2 Purpose of This Document

This reference manual is meant as a technical guideline for dealing with 10 bit and 12 bit L-Log footage. While the main reason to record in log is to maximize dynamic range and latitude in post production, it can be important for certain applications to be able to match footage from different sources in a defined manner. Requirements for this matching operation are the definition of the log curve and the color space used for recording, both of which are provided in this document. Additionally, section 5, 6, 7 and 8 include practical guidelines and tips for working with L-Log footage successfully.

3 L-Log Curve Characteristics

The L-Log gamma curve is plotted in Figure 1. Linear scene reflection (LSR) values are mapped to L-Log values following the calculation specification described in subsection 3.1.

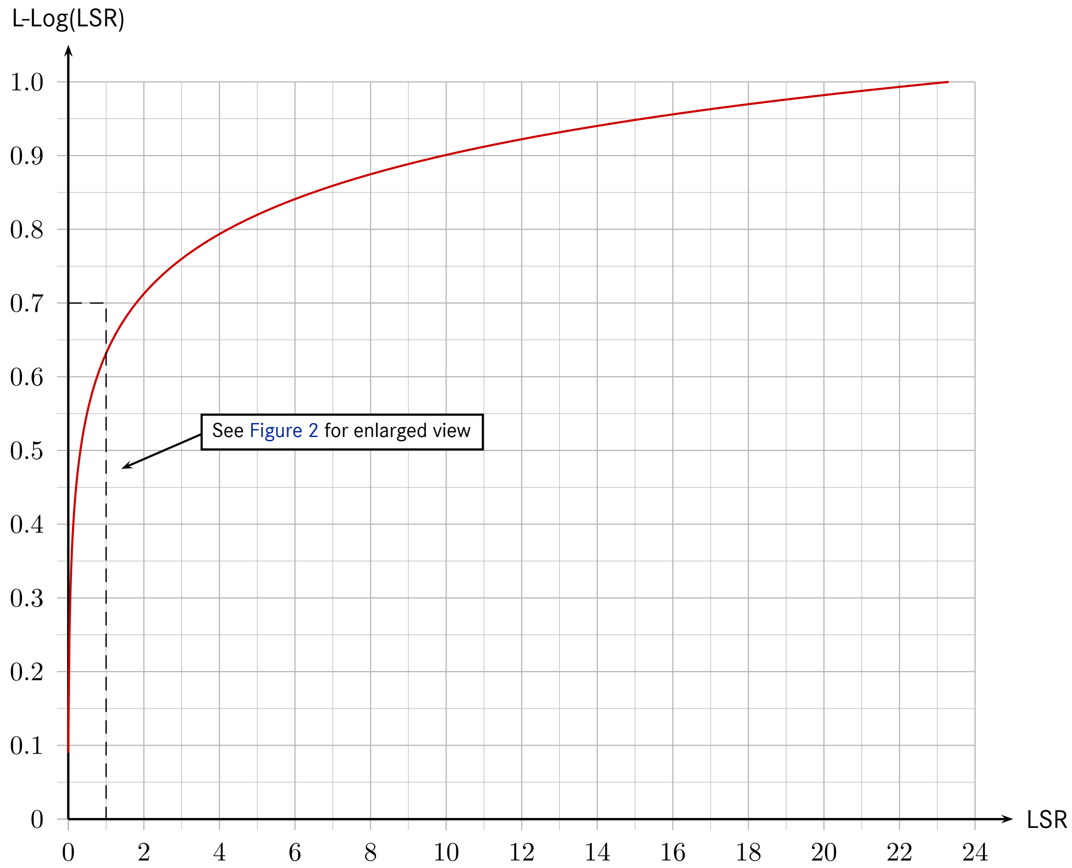

Figure 1: Extended L-Log curve showing when L-Log(LSR) value approaches 1.0.

Figure 2 shows the L-Log gamma curve plotted until it reaches an LSR value of one.

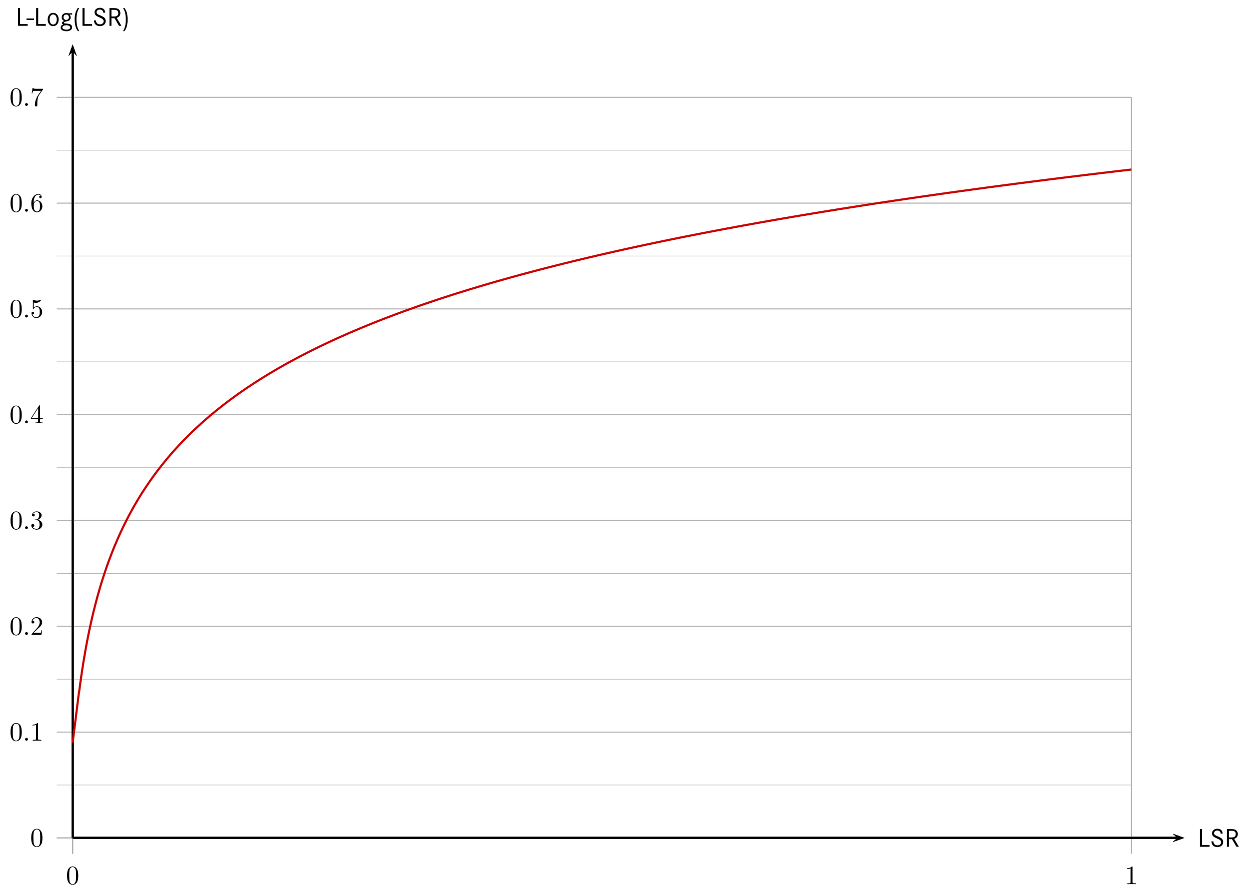

Figure 2: L-Log curve plotted until an LSR value of one is reached.

3.1 LSR-to-L-Log Conversion

For LSR-to-L-Log conversion the following calculation specification is given.

$$\text{L-Log(LSR)} = \begin{cases} a \cdot \text{LSR} + b & \text{for LSR} \leq 0.006 \\ c \cdot \log(d \cdot \text{LSR} + e) + f & \text{else} \end{cases} \tag{1}$$

where

$$a = 8$$
$$b = 0.09$$
$$c = 0.27$$
$$d = 1.3$$
$$e = 0.0115$$
$$f = 0.6$$

3.2 L-Log-to-LSR Conversion

For L-Log-to-LSR conversion the following calculation specification is given.

$$\text{LSR} = \begin{cases} \frac{\text{L-Log(LSR)}-b}{a} & \text{for L-Log(LSR)} \leq 0.1380 \\ \frac{10^{\left(\frac{\text{L-Log(LSR)}-f}{c}\right)}-e}{d} & \text{else} \end{cases} \tag{2}$$

where

$a = 8$
$b = 0.09$
$c = 0.27$
$d = 1.3$
$e = 0.0115$
$f = 0.6$

3.3 Mapping of LSR to IRE, DV and EV

Typical LSR values and their equivalent in IRE[1], 10 bit and 12 bit digital values (DV) as well as exposure values are given in Table 1 along with a practical meaning of each entry in the table.
Figure 3 shows a plot of the relationship between digital and exposure values.

LSR		IRE	L-Log Digital Value		Exposure	Practical Meaning
	[%]	[%]	10 bit	12 bit	Value	
0.00	0	3	92	369	-8.0	Black Level
0.02	2	18	220	880	-3.1	2% Black
0.18	18	44	445	1782	0.0	Middle Gray
0.90	90	65	634	2537	2.3	90% White
4.07	407	86	814	3258	4.5	SL3 White Limit
5.59	559	90	852	3410	4.96	SL (Typ 601) White Limit
8.15	815	95	897	3590	5.5	SL2 / SL2-S White Limit
23.30	2330	109	1023	4095	7.0	L-Log White Limit

Table 1: Typical LSR values and their equivalents in IRE, L-Log digital values and exposure values.

L-Log is defined to offer a maximum dynamic range of 15 stops (as illustrated in Figure 3 and Figure 4). The maximum dynamic range each camera model can achieve is reflected in different white clipping limits. For reference, these values are listed in Table 2 for each camera capable of recording L-Log footage.

Camera	Clipping Value	
	10 bit	12 bit
SL3	814	–
SL (Typ 601)	852	–
SL2, Q3	897	–
SL2-S	897	3590

Table 2: L-Log clipping values for different cameras.

[1] See https://en.wikipedia.org/wiki/IRE_(unit)

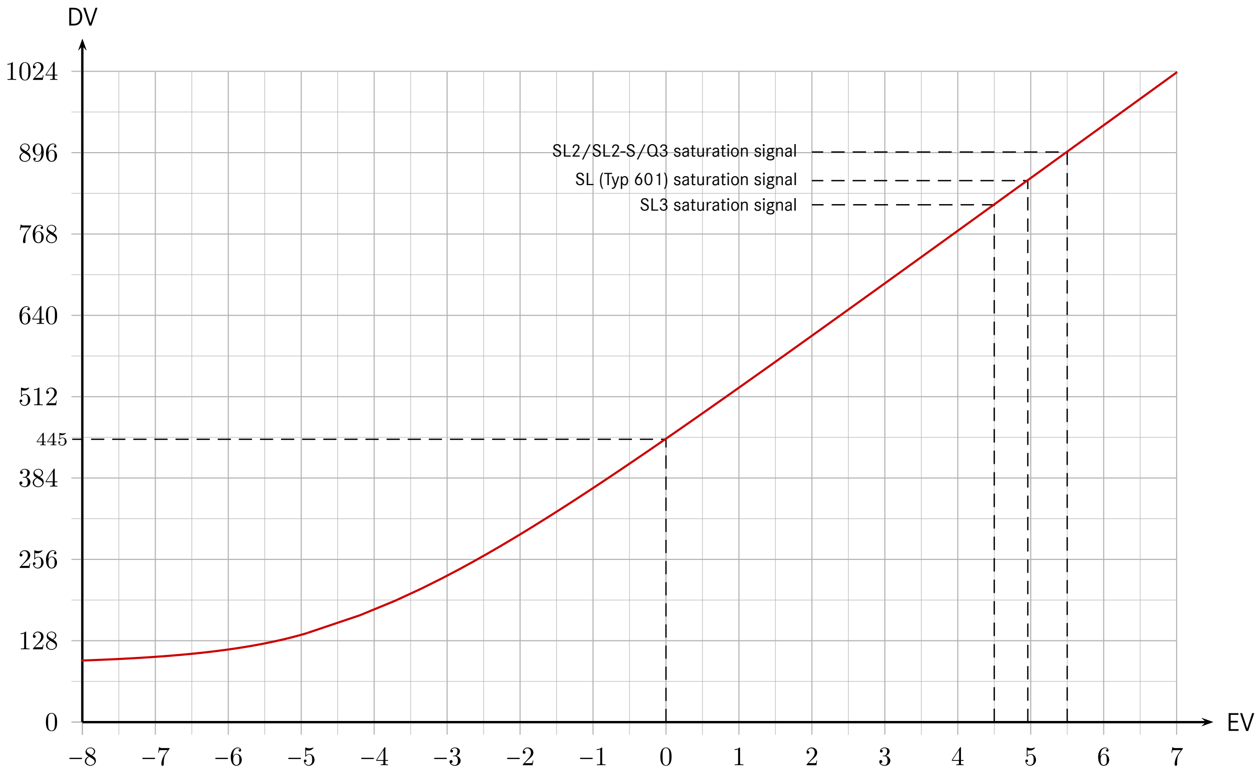

Figure 3: Relationship between linear scene reflection in exposure values and corresponding 10 bit digital values of the L-Log curve. The value of 0 EV corresponds to 18% input reflection.

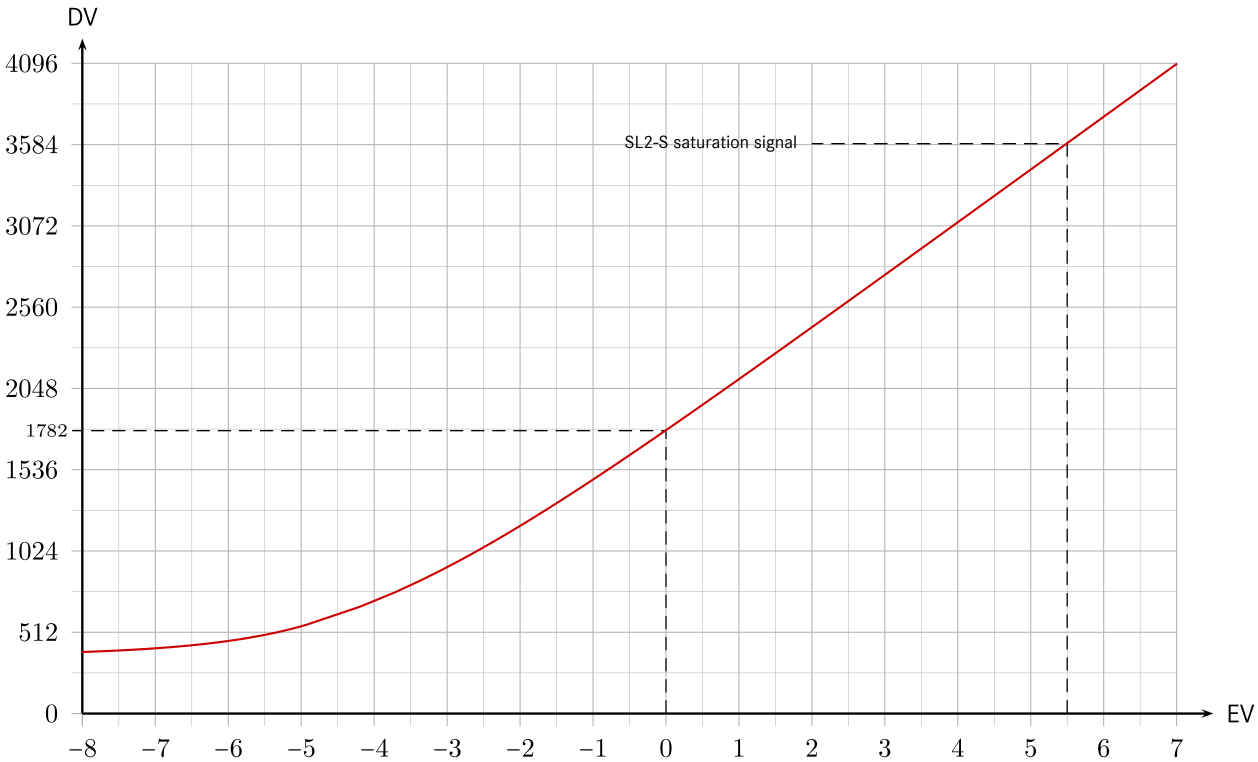

Figure 4: Relationship between linear scene reflection in exposure values and corresponding 12 bit digital values of the L-Log curve. The value of 0 EV corresponds to 18% input reflection.

4 Colorimetric Characteristics

The latest Leica cameras capable of L-Log recording use the ITU-R BT.2020 color space, while the SL (Typ 601) uses the ITU-R BT.709 color space. The properties of both spaces are shown in Table 3.

Figure 5 shows a comparison of common color spaces on a CIE 1931 xy chromaticity diagram.

Camera	Color Space	White Point		Primary Colors					
		x_W	y_W	x_R	y_R	x_G	y_G	x_B	y_B
SL2	ITU-R BT.2020	0.3127	0.3290	0.708	0.292	0.170	0.797	0.131	0.046
SL2-S									
Q3									
SL3									
SL (Typ 601)	ITU-R BT.709	0.3127	0.3290	0.640	0.330	0.300	0.600	0.150	0.060

Table 3: L-Log color space properties.

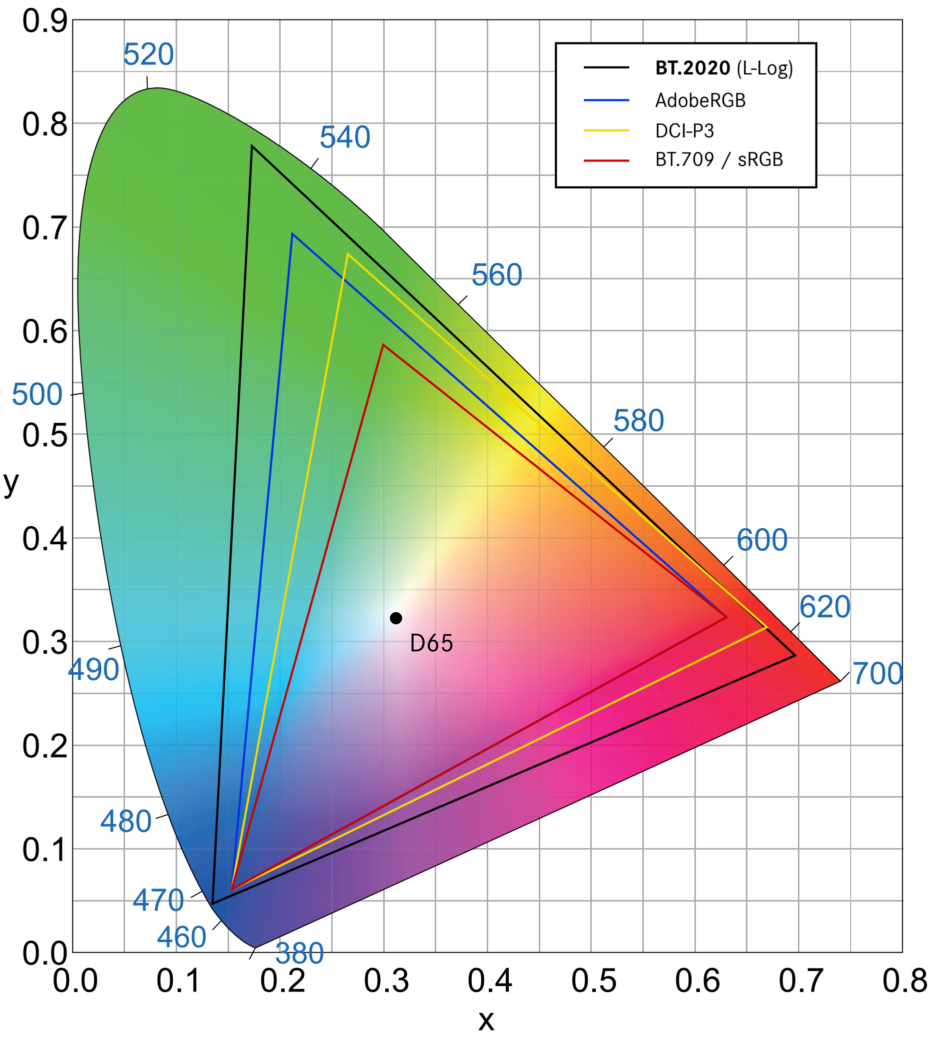

Figure 5: Comparison of color spaces.

4.1 Colorimetric Conversions

Converting from BT.2020 to XYZ color space is defined as:

$$\text{BT.2020 to XYZ} = \begin{bmatrix} 0.6370 & 0.1446 & 0.1689 \\ 0.2627 & 0.6780 & 0.0593 \\ 0.0000 & 0.0281 & 1.0610 \end{bmatrix}$$

The reverse conversion is defined as follows:

$$\text{XYZ to BT.2020} = \begin{bmatrix} 1.7167 & -0.3557 & -0.2534 \\ -0.6667 & 1.6165 & 0.0158 \\ 0.0176 & -0.0428 & 0.9421 \end{bmatrix}$$

Additional colorimetric conversions (i.e. between BT.2020 and BT.709) can be found in relevant literature.

5 Camera Settings for Recording L-Log

In order to record L-Log footage the appropriate Video Gamma setting must be enabled in the Settings menu:

SL2, SL2-S, Q3	**Video Settings** ▶ **Video Gamma** ▶ select **L-Log**
SL (Typ 601):	**Video Settings** ▶ **Video Gamma L-Log** ▶ select **On**
SL3:	**Video Profiles** ▶ **Profile [1–5]** ▶ select **L-Log** in lower left corner of selection matrix

Some cameras come with an option to output a viewing LUT via HDMI. This feature can be used when a monitor is connected to the HDMI port, but should be avoided when the HDMI signal is being recorded. In order to record a clean L-Log signal externally the following options should **not** be set to **HDMI**:

SL2, SL2-S, Q3	**Video Settings** ▶ **Video Gamma** ▶ **Settings** ▶ **L-Log** ▶ **Output**
SL3:	**Log Settings** ▶ **L-Log Settings** ▶ **Output**

In case no **LUT Profile** has been set, the **Output** option can be ignored.

RAW Video: in the case of the Leica SL2-S it is possible to record L-Log as 12 bit RAW footage via an external recorder. To enable this feature "HDMI RAW" must be selected in the "Video Format / Resolution" menu and a compatible recorder must be connected via HDMI (see section 6).

6 Recording L-Log Externally

In order to record an L-Log signal via HDMI the camera must be set to output L-Log, which is ensured by selecting the appropriate gamma setting (as described in section 5). The recorder can be set to display the signal "as is", showing the "flat" appearance of the log footage. Or it can be set to apply a viewing LUT to give the camera operator a better idea of the final result (i.e. in ITU-R BT.709 color space and gamma). Suitable LUTs for this purpose can be uploaded to the recorder.

It should be noted that LUTs can also be "baked in", effectively recording the footage in the final look that the LUT provides. In most cases this should be avoided, because it limits the advantages of recording log footage and therefore represents a rather impractical workflow.

RAW Video: an externally connected video recorder must be set to accept a RAW video input via HDMI. Currently, the following recorders are supported:

Manufacturer	Model	Recording Format
Atomos	Ninja V	ProRes RAW, ProRes RAW HQ
	Ninja V+	ProRes RAW, ProRes RAW HQ
Blackmagic Design	Video Assist 12G HDR	Blackmagic RAW (BRAW)

Specific Atomos Ninja Settings:

- Matching the camera signal in the “CAMERA OUTPUT” section on the “Input” tab is only required for in-recorder HDR processing. For typical workflows “Log/HDR” can remain off.
- When a RAW video signal is detected by the Ninja the camera output parameters are detected automatically.

7 Exposing L-Log

There are two approaches to exposing L-Log:

Easiest LUT application: this is the exposure that L-Log LUTs are designed for.

Best image quality (recommended): this is the exposure that ensures that the best image quality and dynamic range are achieved, but it requires exposure correction in post if an L-Log LUT is intended to be used.

The following subsections describe each approach in more detail.

7.1 Exposing for Easiest LUT Application

Since L-Log is designed to reproduce middle gray (18% reflectivity) at 44% IRE, it is important to hit this exposure relatively accurately if one desires do use LUTs designed for L-Log without any exposure correction in post. This means that the shot should include a gray card in the frame and a waveform monitor to help gauge the exposure.

Figure 6 shows a scene with a gray card placed in it and the corresponding view of a waveform monitor. The exposure in this case is dialed in so that the gray card is exposed at about 44% IRE.

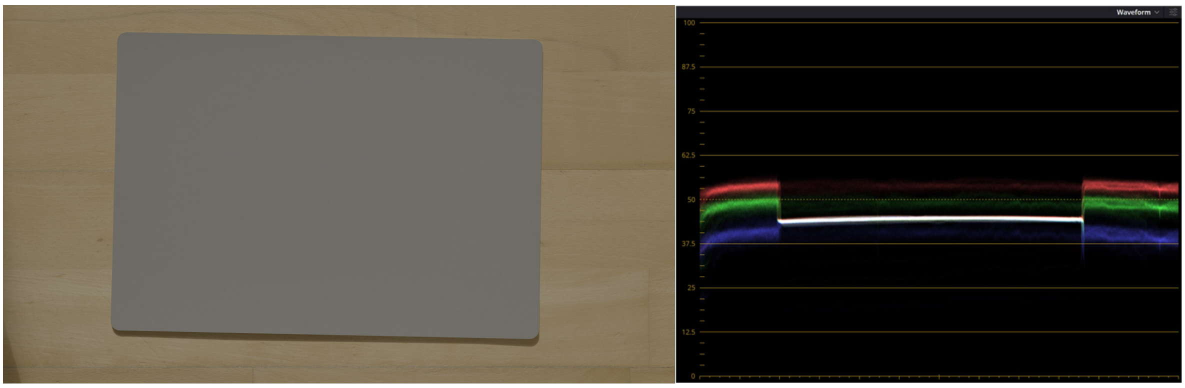

Figure 6: Left: gray card placed in the scene to set exposure; right: waveform monitor view of the scene on the left showing an exposure of the gray card of approximately 44% IRE.

7.2 Exposing for Best Image Quality

In case the goal is to capture the highest dynamic range along with the cleanest shadows with L-Log, the exposure should follow the principle of ETTR (exposure to the right). With this technique the footage is exposed as bright as possible without clipping anything in the highlights that is important to you as the cinematographer.
When this approach is pursued it is important to remember that an exposure correction is necessary in post if a LUT is used that was designed for L-Log. Figure 7 shows the result of an L-Log LUT being applied to an image that was recorded brighter than what the LUT is designed to work with. If the LUT is applied before the exposure has been corrected, as shown in Figure 8, the result is plagued by posterization issues and thus a very flat impression. This issue is often much more subtle than in the given example, in which case it will typically be most noticeable in faces and show up as flat areas where details and gradients should be visible.
The correct handling of this approach is illustrated in Figure 9, where the LUT is applied after the exposure correction to conform the exposure of the footage to that which the LUT was designed for.

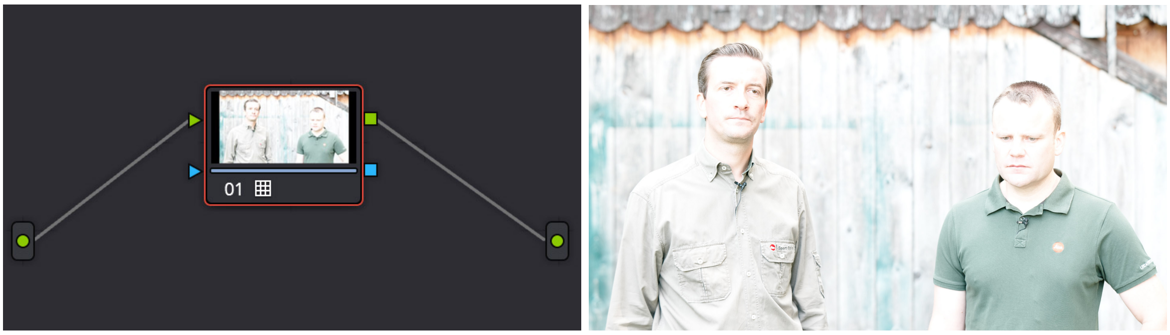

Figure 7: LUT applied to ETTR footage without exposure correction.

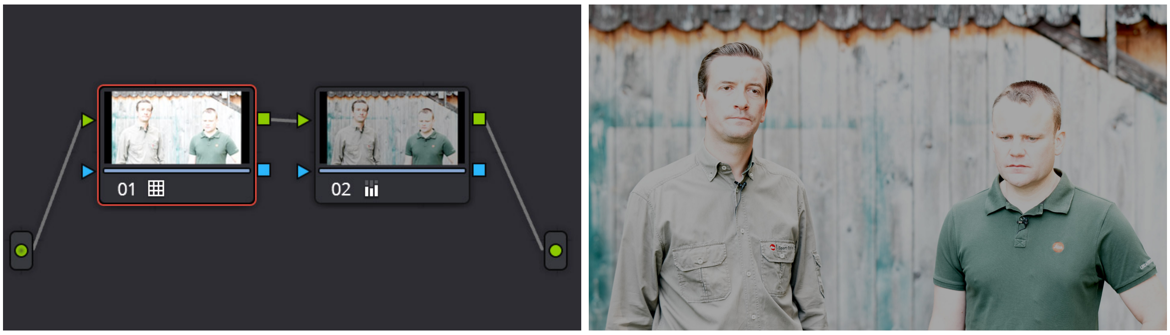

Figure 8: LUT applied to ETTR footage before exposure correction.

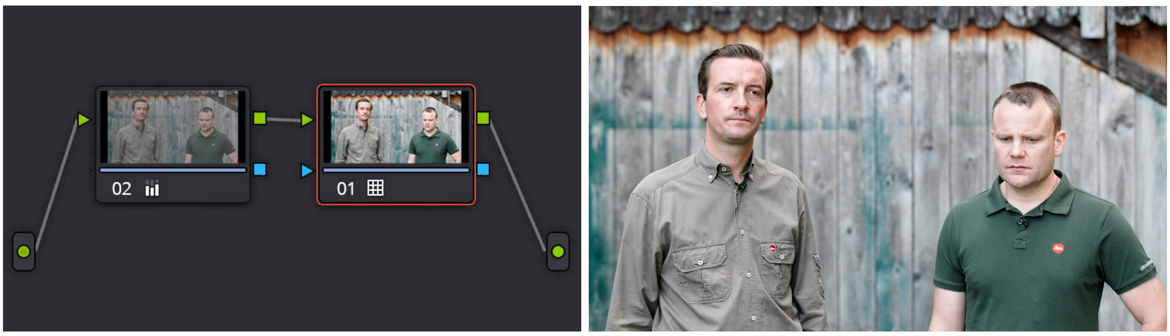

Figure 9: LUT applied to ETTR footage after exposure correction.

8 Editing L-Log Footage

Non-RAW recorded L-Log footage can be edited just like any other log footage as long as the recorded format (container, codec, etc.) is supported by the editing application. Leica provides several LUTs to allow the editor to make use of an out-of-the-box look for both ITU-R BT.709 and BT.2020 workflows. These LUTs can be downloaded from the Leica website.

L-Log is recorded with the full data range ($0-1023$ for 10 bit) instead of video levels ($64-940$). Depending on the software that is used to postprocess L-Log it might be necessary to manually set the levels to full data range to be able to correctly judge the contrast and colors of the recorded material. By recording a scene with over- and underexposed elements the correct interpretation can be verified with a waveform monitor as illustrated in Figure 10 and the values from Table 1.

Please note that the provided L-Log LUTs were not designed to work with the Leica SL (Typ 601) since it records L-Log in the BT.709 color space.

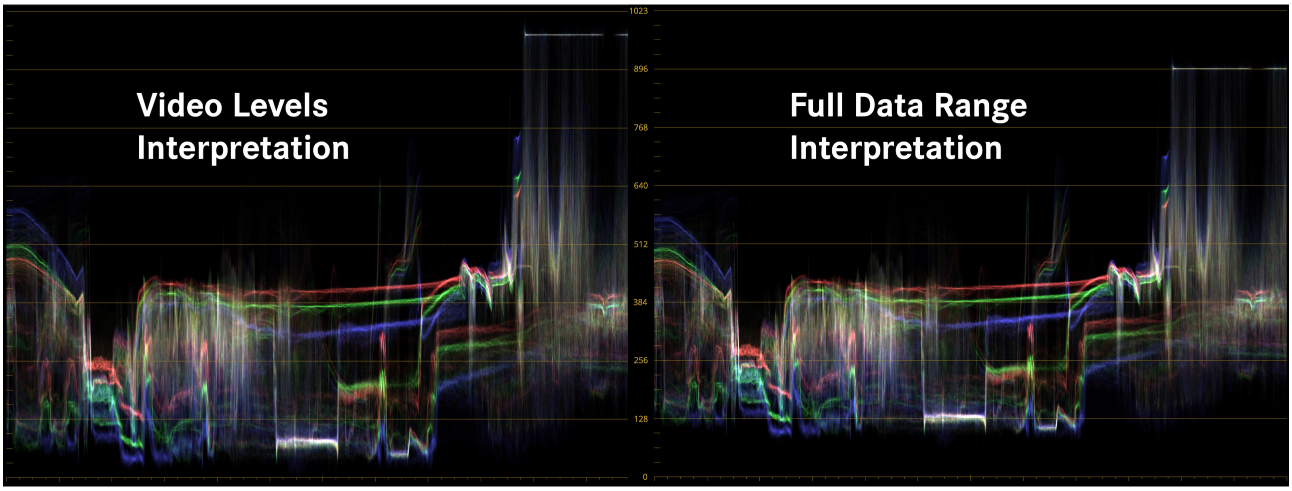

Figure 10: Comparison of L-Log interpretation with video levels and full data range.

RAW video recorded with the SL2-S allows for the following changes in editing software that are not available with non-RAW footage. The following overview lists Adobe Premiere Pro ("Premiere"), Apple Final Cut Pro ("FCP") and Blackmagic Design DaVinci Resolve ("Resolve") capabilities at the time of writing. These capabilities are subject to change without notice.

Adjustment	Apple ProRes RAW	Blackmagic RAW
White Balancing	FCP	Resolve, Premiere
ISO	FCP	Resolve
Exposure	FCP, Premiere	Resolve, Premiere
Interpretation (Color Space, Gamma)	FCP, Premiere	Resolve, Premiere

9 Explanation on Higher ISO Value in L-Log

While recording L-Log the camera shows a higher ISO value compared to when a standard gamma is used. This does not reflect a different sensor gain. Instead, this change is required to increase consistency of the brighter middle gray rendering of the log curve with the applicable ISO standard[2]. The brighter middle gray rendering of L-Log allows for a lower exposure, which in turn affords more dynamic range to be allocated to the highlights.
Figure 11 illustrates the difference in brightness of middle gray.

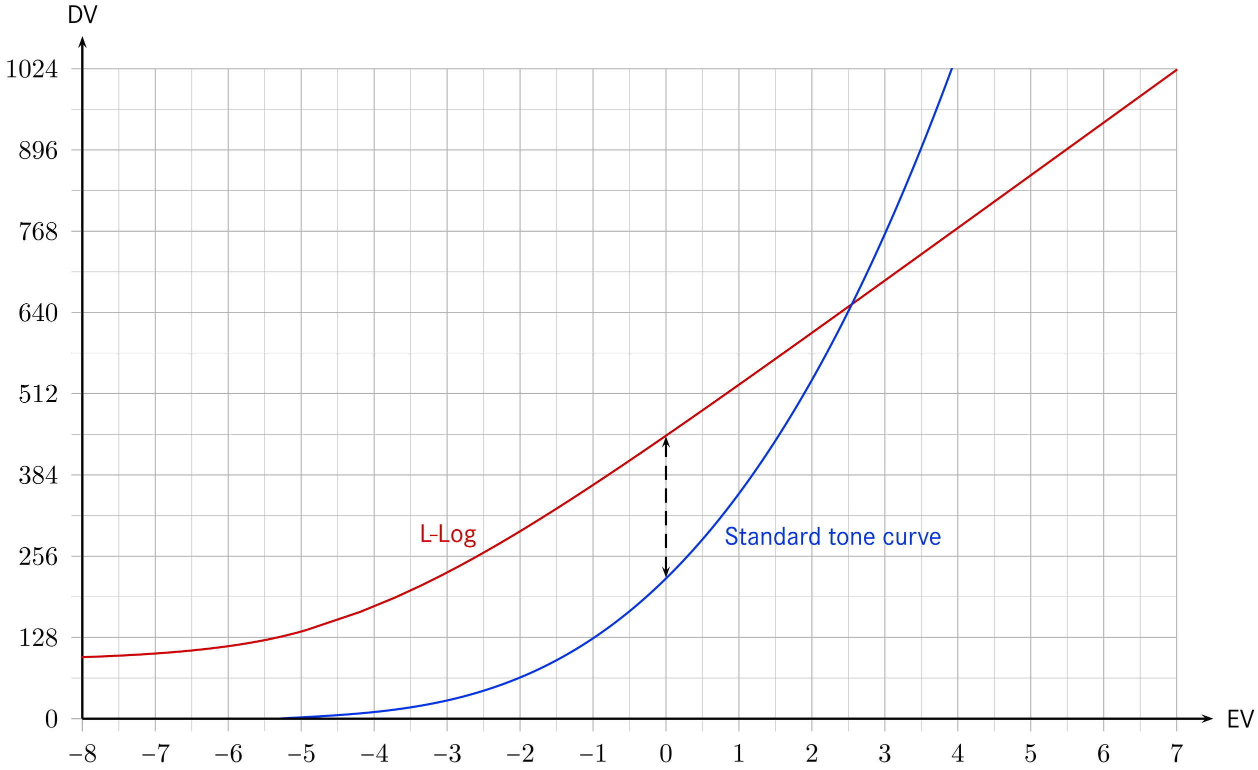

Figure 11: Comparison of L-Log curve with standard tone curve.

[2] ISO 12232

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