

Sony Corporation

S-Log White Paper

S-Log within Digital Intermediate workflow designed for cinema release

Version 1.12.3

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1 S-Log Characteristics

The S-Log gamma function is optimized for Digital Motion Picture camera. The logarithmic camera encoding curve was carefully designed by analyzing the noise floor characteristics and the tonal reproduction of the imaging device. Since negative film stock and the CCD or CMOS imager behave differently to incoming light, especially in the low-light and high-light region, the S-Log curve differs from Log curves for film based images. CCD or CMOS imagers respond to incoming light in a far more linear fashion than film, thus there are no “toes” or “shoulders”. The S-Log curve provides sufficient quantization bits to offer exceptional tonal reproduction in both the low-light and high-light region. The appearance on a monitor is also taken into consideration, so that an S-Log image could be viewed using an appropriate display LUT (Film Print Emulation and/or S-Log to Rec 709). When shooting in S-Log, as distinct from ITU-R BT. 709 (Rec 709) video gamma, a color grading (‘look management’) process is mandatory to establish a desired reference ‘look’ (color; contrast) for dailies and editorial. This color graded ‘look’ should be related to a target output display, e.g., film print projection; digital cinema projection. When viewing S-Log encoded images on an HD reference monitor that are ultimately intended for cinema release via film print and D-cinema projection, a display LUT should be applied that emulates film print or digital cinema color and contrast within the constraints of the video monitor’s gamut and contrast. Using the traditional photo-chemical analogy, S-Log is the “camera negative” and the final look of the “release print” and DCP is ultimately defined during the final color grading in the Digital Intermediate post production process.

When converted to a DPX Log file for a Digital Intermediate post workflow, S-Log encoded images requires the transform function of an Input Conversion Transform (ICT) (NB: see three examples below) to adjust the slope/shape of its ‘gamma curve’ to be compatible with Cineon Print Density specifications. (NB: Cineon Print Density specifications are based on a scanned film negative as input source.) This adjustment is necessary so that a film print emulation Look Up Table (LUT) can be non-destructively applied to S-Log encoded images for the final color grading intended for theatrical release on film print and digital cinema

Three examples of ICTs are:

- ASC CDL functions which include “Power,” (gamma) “Offset”(lift) and “Slope” (gain). (NB: ASC CDL description added as appendix) (Fig 6 to be added)

- Sony LUT (Kawada LUT - 10bit S-Log to 12 bit Cineon, see Fig5 (page 12). Purpose of this LUT is to conform 'S' Log DPX Files to Cineon print density for compatibility with a film print emulation display LUT for color grading.
- Using image processing tool sets internal to a color corrector as an ICT (Fig 7 to be added)

When color grading S-Log images within a film-centric DI post workflow, there are powerful color grading tool sets incorporated within modern color correction systems that enable the potential to achieve optimum results without necessarily having to apply an 'external' ICT 'pre-set' (S-Log-to-Cineon LUT or ASC CDL Power Function) which conforms the gamma slope of S-Log image data to match Cineon print density. If this alternate color grading path is chosen (preferably working with a skilled and experienced colorist), it is crucial to ensure that the color corrector being used does not surreptitiously apply unwanted 'behind-the-scenes' transforms during the S-Log image ingest stage or during internal image processing and/or does not apply inappropriate OCTs (Output Conversion Transforms) for an incorrectly targeted output display device (e.g., Rec.709 projector or monitor). Having disabled any unwanted hidden transforms, the rendering transform for an appropriately targeted output (e.g., a film print emulation LUT) can then be purposefully applied non-destructively to S-Log image data for optimum color grading results.

It is also important to note that, whether or not an ICT 'pre-set' (S-Log-to-Cineon LUT or ASC CDL Power Function) is used to adjust the S-Log gamma slope to conform with Cineon print density when using a film print emulation LUT, optimized color grading results for S-Log encoded images will best be achieved when the color corrector is configured to 'do nothing' unknown behind-the-scenes. This will eliminate the threat of any detrimental impact that inappropriate transforms might have on S-Log image content. The full scope of the color corrector's grading tools can then be properly applied to take full advantage of S-Log's extended dynamic range and wide color gamut.

When capturing an extended dynamic range of scene tones is the priority, the recommended exposure index for the F35 is 500 ISO (MASTER GAIN 0dB.). In order to achieve the widest dynamic range, the camera needs to be set to the Cine Mode (EXTEND mode). The camera will resolve 5.3 T-stops above 18% neutral gray . (800% in video terms) See Figure Table 1.

Table 1 F35 Dynamic Range in Cine Mode

ISO	S/N	Exposure Latitude over 18%	Exposure Latitude below 18%	Total Latitude (Dmin to Dmax)
450	54.5dB	+5.3 Stop	-6.8 stop	12.1 Stops
500	53.6dB	+5.5 Stop	-6.6 stop	12.1 Stops
640	51.5dB	+5.6 Stop	-6.3 stop	11.9 Stops

Selecting the (EI) Exposure Index (ISO) setting for the F35 configured in Cine Mode S-Log

Selecting the optimal EI (ISO) setting for the F35 configured in Cine Mode S-Log is based on ensuring that the full dynamic range of up to 12 stops of scene tone scale exposure values (scene luminance range from minimum shadow detail to maximum highlight detail carefully measured with a properly calibrated photometric spot meter) can be effectively captured (“Dmin” to “Dmax”).

In general, an EI of 500 ISO should be used, but 640 ISO can also be effectively used as a $\frac{1}{3}$ stop exposure latitude margin to further ensure that a scene’s brightest highlight luminance(s) will be protected from possible clipping due to a potential error in spot meter reading and/or calibration drift of the photometer. Since the F35 configured in S-Log Cine Mode has greater exposure latitude under 18% (6.8 stops), reproduction of scene luminance(s) representing minimum shadow detail can be captured using an EI of 640 ISO without clipping.

Using Input Conversion Transform (ICT) to adjust S-Log gamma function to Cineon

When shooting in S-Log, actual digital code values that represent scene tone scale values do not directly correspond with code values that are assumed when using a conventional photographic exposure meter (which assumes film density code values). Such discrepancy between the digital camera recorded “density” and the exposure meter readings are caused by the characteristics of the S-Log gamma function which are different from film gamma function (see graph below). When an appropriate ICT Look Up Table (LUT hereunder) is applied during on-set look management and/or in the post production process, the discrepancy will diminish (see Fig. 2 below). The basic characteristic of the S-Log gamma function (without LUT treatment) is shown in Fig. 1.

Fig. 1 Characteristic curve of S-Log

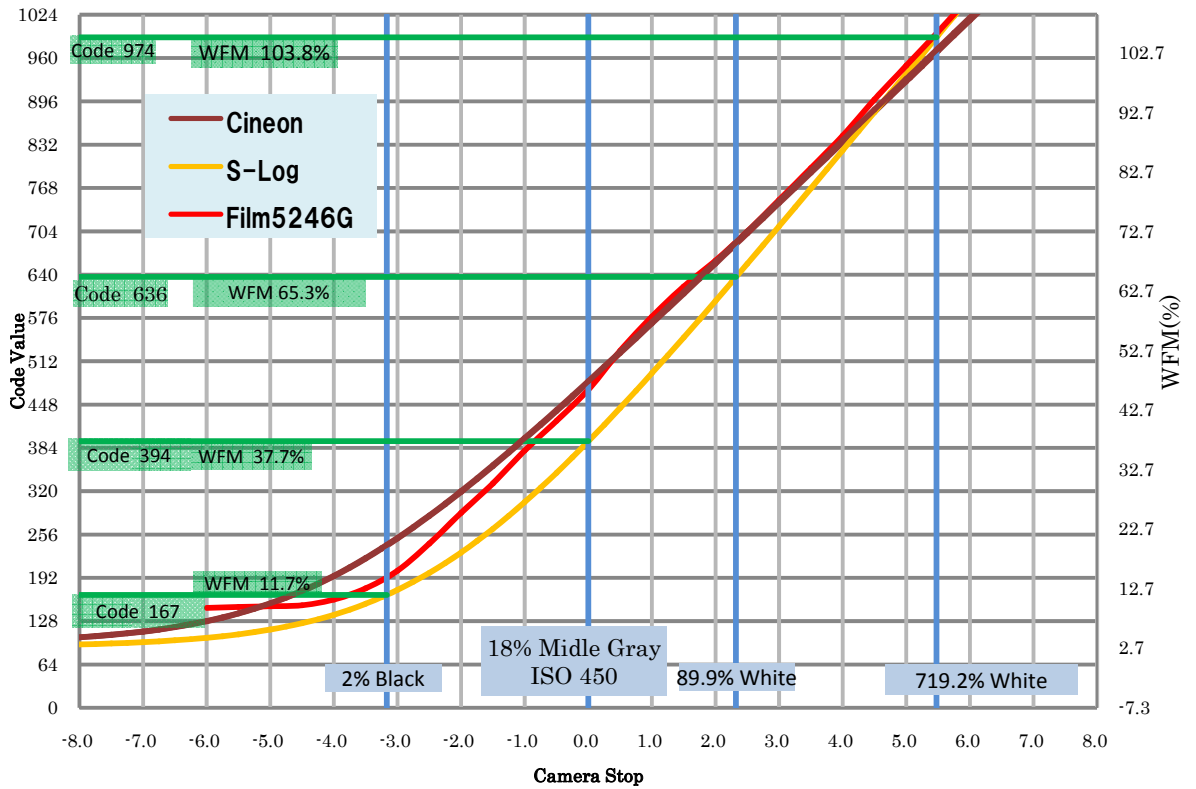


Table 2 S-Log Code Values

Chart Reflection (%)	ISO450 Video Input (%)	ISO450 Waveform Monitor (%)	ISO500 Video Input (%)	ISO500 Waveform Monitor (%)	ISO640 Video Input (%)	ISO640 Waveform Monitor (%)	Code Value
0.00	0.00	3.0	0.00	3.0	0.00	3.0	90
2.00	2.22	11.7	2.00	11.01	1.56	9.53	167
18.00	20.02	37.7	18.02	36.01	14.08	32.26	394
89.90	100.00	65.4	90.00	63.45	70.31	59.02	636
719.20	800.00	103.8					974
799.11			800.00	103.8			974
1022.86					800.00	103.82	974

Table 3 Cineon Code Values

Reflection (%)	Code Value
2	220
18	470
90	685

Log Attribute in Quantel system: Dmin = 90, Dmax = 974.

1.1 Changing the Sensitivity (Push/Pull Process)

The most common method is to adjust the MASTER GAIN of the camera as shown in Table 4

Table 4 F35 Sensitivity

MASTER GAIN	-6dB	-3dB	0dB	3dB
Latitude	400%	550%	800%	800%
Camera Stop	4.3	4.8	5.3	5.3

1.1.1 Normal Sensitivity

F35: ISO 500 Cine Mode, MASTER GAIN 0dB

1.1.2 Push Process

Increasing camera gain will increase camera sensitivity but will increase the camera noise floor.

1.1.3 Pull Process

Reducing the camera gain will improve the signal to noise ratio performance. It is suited for blue/green screen effects shots where pulling a clean key is of prime importance.

Chart 1. Comparing the Differences in Effects of Push/Pull Processing between S-Log and film

	Push processing(+ve Gain)			Pull Processing (-ve Gain)		
	Contrast	Latitude	Graininess	Contrast	Latitude	Graininess
Film	Increases	Narrows	Increases	Reduces	Widens	Decreases
S Log	No changes	No changes	Increases	No changes	Narrows	Decreases

1.2 On-set Monitoring

1.2.1 Camera Viewfinder

The camera viewfinder should be used for composition/framing only since it is not suitable for monitoring reference quality image display. Depending on the camera operator's preference, the viewfinder can display S-Log with no viewing LUT applied if he/she wants to see the full dynamic range capture by the sensor, or the viewfinder can be set for a more 'normalized' contrast by using a display LUT if that is more important for accuracy of scene composition/framing.

1.2.2 Monitoring with the BVM-L230/L231

The BVM-L230/L231 is equipped with TWO gamma function settings to monitor S-Log input signals. "S-Log Standard" converts the reflectance level of 90% gray to the BVM-230's luminance level of 100%. The look of the image will be similar to that of video assist systems integrated into film cameras. The BVM-L230/L231 can reproduce highlights up to x1.32 times of 90% gray; however any further highlight information will be clipped. The overall image contrast will look close to how the human eye sees.

The "S-Log FULL" mode displays the full latitude (0% – 800%) of the S-Log signal. Select this setting when you wish to check the entire dynamic range of the image that is being captured. Note that the displayed image will appear very dark on the BVM-L230 as the camera's entire latitude is mapped within the monitor's 100% level.

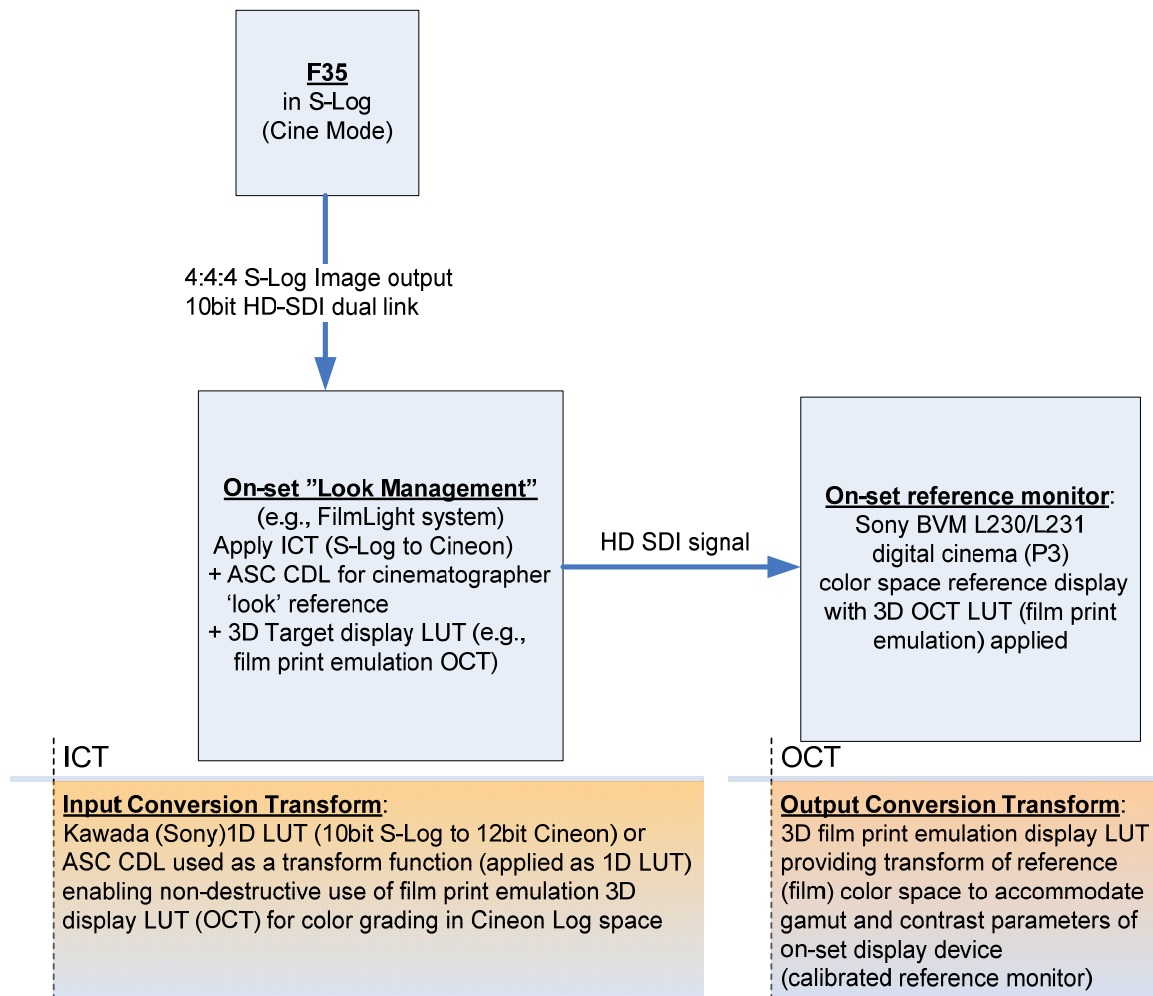
1.2.3 Display LUTs for on-set look management of image reference monitoring

For on-set look management reference monitoring (e.g., BVM-L231 or BVM-L230) of S-Log image output from camera, a display LUT (OCT: Output Conversion Transform) should be applied to adjust contrast & color reproduction (within the gamut and contrast parameters of the on-set reference monitor) to more closely match the output of primary target display devices, i.e., Digital Cinema Projection and Film Print Projection.

1.2.4 On-Set Look Management

On-Set Look Management can be applied by way of one or more pre-set looks (usually 3D LUTs) that combine the ICT, a "best-light" color correction, and the OCT for the on-set monitor. It is also possible to use on-set systems that allow you to proactively adjust the color correction of shots and scenes in-between the ICT and OCT, emulating the color processing used in final color correction.

Fig. 3 S-Log On-set Look Management workflow with ICT and viewing LUT (OCT) applied for target output display



2 S-Log material in Post production

Images captured in S-Log can be processed in various ways. The choice of the post production workflow depends on the final output of the project (Film out, Digital Cinema release, & TV Broadcast) , When running a camera test, it is highly recommended to pay attention to the entire production and post production workflow process, since it can significantly alter the test result. This White Paper addresses the way to handle S-Log camera original material in a Cine-based ‘film-centric’ Digital Intermediate post production workflow designed for cinema release on both print film and digital cinema (DCP).

2.1 Working with S-Log in CINEON space

Very similar to how film based materials are scanned, ingested, and processed in Cineon Log space today, S-Log material can be directly processed by color grading systems that are capable of handling Cineon LOG based DPX image data files by first applying an Input Conversion Transform (ICT) function, e.g., Kawada S-Log to Cineon LUT or other “pre-set” LUT, the ASC CDL ”Power” (with optional “Offset” and “Slope”) function(s) or applying an internal color corrector transform to conform S-Log gamma slope/shape for compatibility with the Cineon print density log curve. Since the resulting S-Log gamma characteristics with the appropriate ICT applied are very close to those of camera negative stocks, color grading can then be performed using a color corrector in a manner similar to a scanned film negative. In order to make color grading decisions, an appropriate output conversion transform (OCT), i.e., a film print emulation LUT needs to be applied within the system.

A film print emulation VIEWING LUT converts the S-Log DPX materials to film print color space and contrast.

LUT`s can be applied within compositing tools such as the Autodesk Inferno system, in addition to the most frequently used color corrector systems, i.e., Autodesk Lustre, Quantel Pablo, FilmLight Baselight, DaVinci 2k and Resolve, and Digital Vision Film Master.

Fig. 4 S-Log Workflow from Image Capture through DI

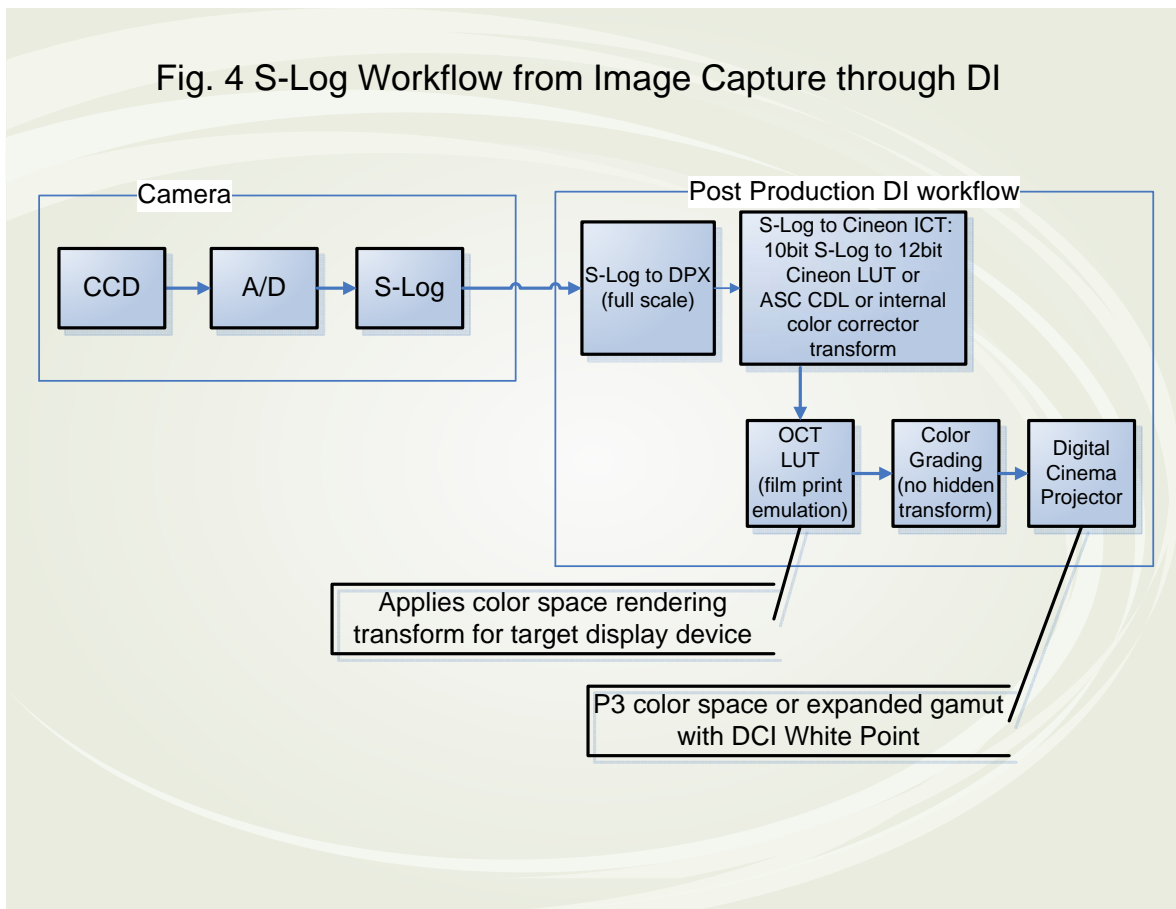
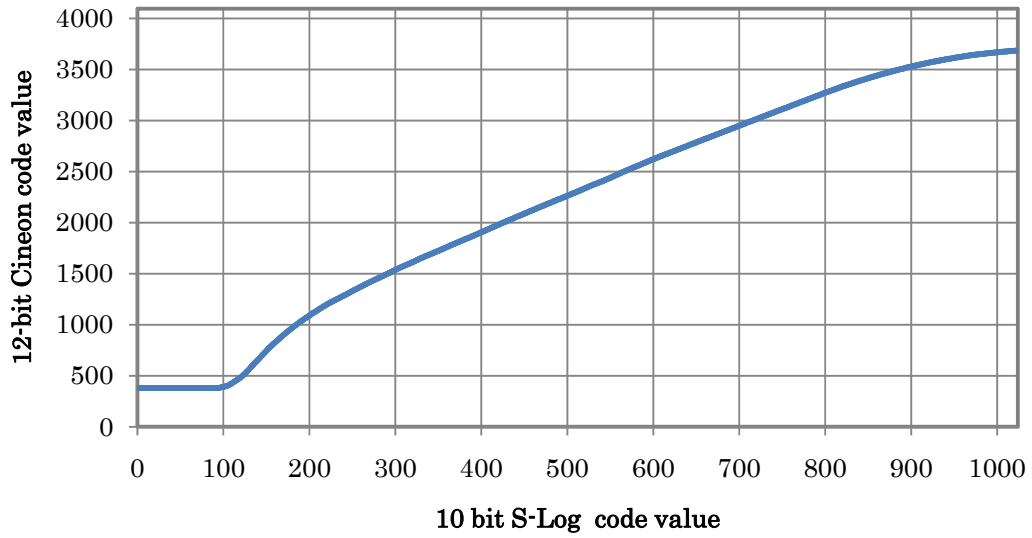


Fig. 5 S-Log to Cineon

S-Log to Cineon



3 S-Log Formula

The formula representing the S-Log curve is as follow.

$$y = (0.432699 * \text{Log}_{10}(t + 0.037584) + 0.616596) + 0.03$$

where t ranges from 0 to 10.0, representing 0 to 1000% input light level to a camera.

Multiply y by 100 to get the percentage.

The reverse curve is expressed as follow.

$$Y = \text{Power}(10.0, ((t - 0.616596 - 0.03) / 0.432699)) - 0.037584$$

where t has a range of 0 to 1.09, representing the camera output code of 0 to 109%.

Multiply Y by 100 to get the percentage.

Example for 14bit Input, 10bit Output;

INPUT

Bit Depth: 14bit

Gamma: 1.0 (linear light)

Black Level: 128

Reference White Level: 1880

OUTPUT

Bit Depth: 10bit

Gamma: S-Log A

Black Level: 90

Reference White Level: 636

Min. Output Value: 4

Max. Output Value: 1019

S-Log Formula

$$Y = 379.044 * \text{LOG}_{10}(((X - 128) / 1752) + 0.037584) + 630$$

Anti S-Log Formula

(The formula to reconvert 10bit S-Log to 14bit Linear)

$$y = 1752 * (\text{Power}(10.0, (X - 630) / 379.044) - 0.037584) + 128$$

Example Reverse S-Log 10bit Input reflection output.

 $x = 0 \sim 1023$ (S-Log 10 bit code) $y =$ S-Log input reflection linear-light value (ex. 18% = 0.18)

$$y = (\text{Power}(10.0, (((x / 4.0 - 16.0) / 219.0) - 0.616596 - 0.03) / 0.432699)) - 0.037584) * 0.9;$$

Video IRE value = $y / 0.9$;

4 Appendix

4.1 S-Gamut (Color Space Conversion)

4.1.1 F900 Color Space

This color space should be used when users would like to match colors of images (like F35) to that of conventional Sony's camcorders representing the HDW-F900. S-GAMUT to that for conventional cameras is shown below:

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1.306240 & -0.233075 & -0.073165 \\ -0.126851 & 1.178376 & -0.051526 \\ 0.000120 & -0.085649 & 1.085529 \end{bmatrix} \begin{bmatrix} R_w \\ G_w \\ B_w \end{bmatrix}$$

(R_w, G_w, B_w): RGB values for the original color space for S-Gamut

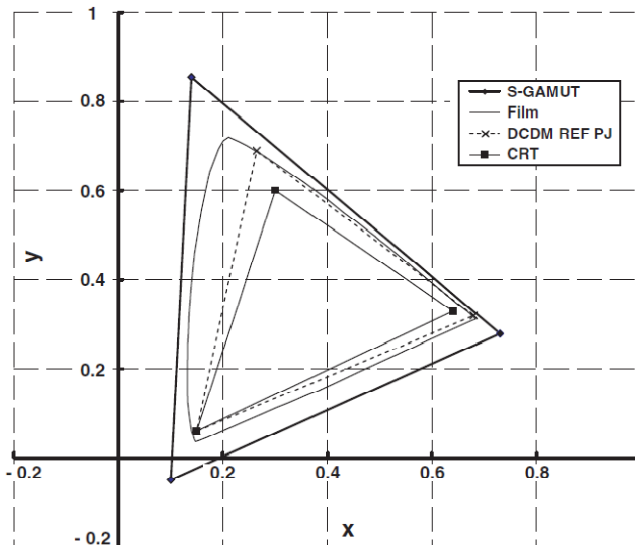
(R, G, B): Values after being converted to the color space for conventional cameras

4.1.2 S-Gamut Color Space

The chromaticities for the S-Gamut primaries are as follows:

	x	y
Red	0.73	0.28
Green	0.14	0.855
Blue	0.10	-0.05

In order to make the best use of the data capturing capability of S-Gamut (wider color space), the process that convert RGB values to the XYZ values by the 3 x 3 matrix.



$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0.7648271319 & 0.2709796708 & -0.0096778454 \\ 0.1288010498 & 0.7866064112 & 0.0046000375 \\ 0.1151721641 & -0.0575860820 & 1.0941355587 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

Where the reference white is D65 (x, y) = (0.3127, 0.3290).

4.2 ASC CDL overview description

The American Society of Cinematographers Color Decision List (ASC CDL) is a framework developed by the ASC Technology Committee that allows the interchange of basic RGB color-correction information between equipment and software made by different manufacturers.

Although the basic controls of most color correction systems are similar, they differ in specific implementation. The terms Lift (for dark tones), Gain (highlights), and Gamma (mid-tones) are commonly used by most color correction systems, but those definitions may vary in detail from system to system and manufacturer to manufacturer.

To avoid confusion and controversy, the ASC proposed a set of three defined transfer functions with unique names: Offset (lift), Slope (gain) and Power (gamma). Each function uses one number for the red channel, a second for the green and a third for the blue. Thus, the three transfer functions for the three color components can collectively be described by nine parameters.

A tenth number, Saturation, was specified in Version 1.2 of the ASC CDL, and is applied to all three channels together.

Revision Record

Ver.	Date	Author	Explanation
Rev 1.11.0	Jan. 26 2009	Norihiko Kawada	First version to distribute
Rev 1.11.1	July 13, 2009	Curtis Clark Patel Dhanendra Jin Yamashita	Customized for film user
Rev 1.12.0	Aug 18.2009	Norihiko Kawada Yuki Osaki Kazuo Endo	S-Gamut Information Release
Rev 1.12.1	Aug. 28 2009	Norihiko Kawada Kazuo Endo	Fig replace
Rev 1.12.2	Oct. 15 2009	Kazuo Endo	Applied Curtis and Patel comment
Rev 1.12.3	Oct. 23 2009	Curtis Clark Patel Dhanendra Kazuo Endo	Added ISO500/640 "IDT" and "ODT" changed to "ICT" and "OCT".