JPLOG2

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1. Introduction

This document presents an in-depth exploration of JPLog2, a logarithmic encoding color space engineered by Josh Pines. JPLog2 was specifically designed to optimize image processing workflows for ultra-high dynamic range (HDR) cameras, which rely on proprietary encoding methodologies unique to each camera manufacturer. By providing a standardized, high-fidelity intermediate color space, JPLog2 surpasses the constraints of existing image processing solutions, enabling superior post-production workflows.

Modern digital cinema cameras employ distinct encoding strategies to capture their extensive dynamic range, necessitating precise transformations for effective color grading and post-production manipulation. Without a dedicated transformation pipeline, images remain constrained by the limitations of proprietary camera encoding spaces, leading to inefficiencies and inconsistencies in color processing. JPLog2 was developed as a response to these challenges, offering a mathematically robust and perceptually optimized encoding solution tailored for HDR image manipulation.

The primary impetus for the development of JPLog2 was the 2022 release of the ARRI Alexa 35, a groundbreaking digital cinema camera renowned for its expanded dynamic range and refined color science. To facilitate high-precision film emulation for this specific camera, JPLog2 was designed as a next-generation encoding space capable of preserving nuanced tonal characteristics while enabling seamless integration with contemporary color grading pipelines. This document explores the mathematical principles, implementation strategies, and practical applications of JPLog2, positioning it as a cornerstone technology in the evolution of digital color science.

2. Problem Statement

The introduction of the ARRI LogC4 hardware encoding curve has presented significant challenges for the post-production and on-set color management workflows. LogC4 represents a logarithmic transformation applied to linear sensor data, utilizing a consistent gamma while being optimized for 12-bit encoding. This enhancement provides superior precision across the sensor's dynamic range compared to LogC3, which was constrained by a 10-bit encoding structure. However, this evolution has introduced practical obstacles, particularly in environments where 10-bit monitoring remains the industry standard.

A critical issue arises from the fact that on-set monitoring workflows still rely heavily on 10-bit signal flow and displays, both for real-time evaluation and post-production color management. 3DLUTS (look-up tables) can also not fully accommodate the increased precision and expanded dynamic range of LogC4, resulting in mismatches between what is captured and what is viewed.

Comparative Analysis of Log Encoding Methods

Name	**ARRI LOGC3**	**ACES CCT**	**ARRI LOGC4**
Gamut	AWG3	AP1	AWG4
Max Linear White	55	222.8	469.8
Mid-Gray	400	423	285
Stops of Dynamic Range*	8.25	10.25	11.35

A comparative analysis of ARRI LogC3, ACES-CCT, and ARRI LogC4 reveals key technical disparities. Historically, ARRI LogC3 has been widely adopted for both camera encoding and post-production due to its balance between dynamic range representation and practical usability. ACES-CCT, the industry-standard log encoding format for intermediate color grading, provides a well-structured encoding framework optimized for color workflows. However, the emergence of ARRI LogC4 introduces a significantly higher maximum linear white, allowing it to encode 11.35 stops of dynamic range above mid-gray, surpassing ACES-CCT's 10.25 stops.

To accommodate this extended dynamic range, ARRI LogC4 reduces the mid-gray level to 285. While this adjustment optimizes stop encoding within the camera sensor, it introduces practical difficulties in color grading workflows.

Impact on Color Grading Workflows

Lift value	0.0	0.3
ARRI LOGC4	128	230
ACEScct	128	200

The shift in mid-gray positioning creates a fundamental issue for standard grading controls, such as Lift, Gamma, Gain (LGG) or Color Decision List (CDL) controls, widely used in professional color grading systems. Due to LogC4's lower mid-gray value, precision in shadow regions is significantly reduced. As a result, even minor adjustments in Lift values introduce substantial variations in black levels.

For instance, a slight 0.3 increase in Lift amplifies black level shifts by 102 code values, making ARRI LogC4 impractical for precise grading operations. This lack of fine control over shadow regions disrupts the predictability of color adjustments and compromises artistic intent, particularly in HDR mastering and film emulation applications.

Moreover, because ARRI LogC4 is the only log encoding currently capable of representing the full dynamic range of the Alexa 35 sensor, it remains the only viable encoding option—yet it proves to be unwieldy for practical use in professional grading environments.

The misalignment between on-set monitoring, log encoding precision, and post-production usability necessitates a new approach to logarithmic color encoding—one that can bridge the gap between ultra-high dynamic range capture and practical grading workflows without compromising precision, usability, or artistic control.

The following sections explore how JPLog2 was developed to resolve these issues, ensuring both high-fidelity encoding and intuitive grading control.

3. Solution

To address the challenges posed by ARRI LogC4, a new encoding solution was developed by renowned color scientist Josh Pines. This encoding, known as JPLog2, was engineered to overcome the practical limitations of ARRI LogC4 while maintaining compatibility with contemporary and future ultra-high dynamic range (HDR) cameras.

The development of JPLog2 was guided by two critical design principles:

1. Fulfill the requirement that the linear dynamic range, represented by 0.0 - 1.0 in the new encoding space, is sufficient for the dynamic range captured by the current and next generation of cameras.
2. Ensure that the encoded value for mid-gray placement and the number of code steps per stop facilitates seamless compatibility with commonly used grading tools, including Lift-Gamma-Gain (LGG) and ASC-CDL (American Society of Cinematographers Color Decision List) adjustments.

Design Approach: Modifying ACES-CCT for Enhanced Usability

As a foundation for JPLog2, Josh Pines selected ACES-CCT, the industry-standard log encoding for digital intermediate (DI) workflows within the Academy Color Encoding System (ACES). ACES-CCT was chosen due to its broad industry adoption, robust mathematical foundation, and adaptability in color grading pipelines. However, key parameters of ACES-CCT were refined and recalibrated.

(Note: While these encoding spaces are commonly referred to as logarithmic encodings, it is important to recognize that they are not purely logarithmic functions. Instead, they contain linear extensions in the low end, making them more accurately described as pseudo-logarithmic encodings.)

Technical Parameters of JPLog2

Through a systematic recalibration of log encoding parameters, JPLog2 was developed with the following characteristics:

1.) Optimized Step Distribution for 10-bit Precision with 50 steps per stop in 10-bit code values above the lin-log crossover point. This ensures smooth gradations in tonal values, minimizing artifacts and quantization errors, particularly in shadow regions.

2.) Mid-gray is set at 400 (10-bit code value), optimizing tonal distribution for grading operations. This positioning results in a normalized log value of 1.0, corresponding to a linear value of 995.998666, which equates to 12.46 stops above mid-gray.

The chart below provides a comparative analysis of the most widely used encoding spaces, including ARRI LogC3, ACES-CCT, ARRI LogC4, and JPLog2, illustrating how JPLog2 achieves an optimal balance between high dynamic range encoding and practical usability for colorists and post-production professionals.

Name	**ARRI LOGC3**	**ACESCCT**	**ARRI LOGC4**	**JPLOG2**
Gamut	AWG3	AP1	AWG4	AP1
Max Linear White	55	222.8	469.8	996
Mid-Gray	400	423	285	401
Stops of Dynamic Range*	8.25	10.25	11.35	12.46

4. Specification and Comparison

a) Comparison between the AcesCCT log encoding and JPLog2

Linear value corresponding to normalized log 0.0

AcesCCT	-0.006917
JPLog2	-0.008756

Linear value corresponding to normalized log 1.0

AcesCCT	222.860944
JPLog2	995.998666

Log 10bit code value corresponding to linear 0.0

AcesCCT	74.582
JPLog2	92.865

Mid-grey (2 ^ -2.5) placement

AcesCCT	422 (10-bit code value)
JPLog2	400 (10-bit code value)

Number of steps per stop in 10-bit log (above the lin/log crossover point)

AcesCCT	58.4 (10-bit code value steps_per_stop)
JPLog2	50.0 (10-bit code value steps_per_stop)

Number of stops from mid-grey to normalized log 1.0

AcesCCT	14.52
JPLog2	17.16

Number of stops from log/lin crossover point to mid-grey

AcesCCT	4.23
JPLog2	4.70

b) 10bit cv's vs integer linear powers of 2.0

10bitcv325 == linear 0.125
10bitcv425 == linear 0.250
10bitcv475 == linear 0.500
10bitcv525 == linear 1.000
10bitcv575 == linear 2.000
10bitcv625 == linear 4.000

c) Linear to JPLog2(0.0-1.0) and JPLog2 to Linear encoding (in 'C')

```
double JPLOG2_LIN_BRKPNT = 0.00680;
double JPLOG2_LOG_BRKPNT = 0.16129;     /* 10bit cv = 165 */
double JPLOG2_LINTOLOG_SLOPE = 10.367739;
double JPLOG2_LINTOLOG_YINT = 0.0907775;


double jplog2_to_lin (double in)
{
   if (in <= JPLOG2_LOG_BRKPNT)
      return (in - JPLOG2_LINTOLOG_YINT) / JPLOG2_LINTOLOG_SLOPE;
   else   /* if (in > JPLOG2_LOG_BRKPNT) */
      return pow( 2.0, in * 20.46 - 10.5);
}

double lin_to_jplog2 (double in)
{
   if (in <= JPLOG2_LIN_BRKPNT)
      return JPLOG2_LINTOLOG_SLOPE * in + JPLOG2_LINTOLOG_YINT;
   else   /* if (in > JPLOG2_LIN_BRKPNT) */
      return (log(in)/log(2.0) + 10.5 ) / 20.46;
}
```

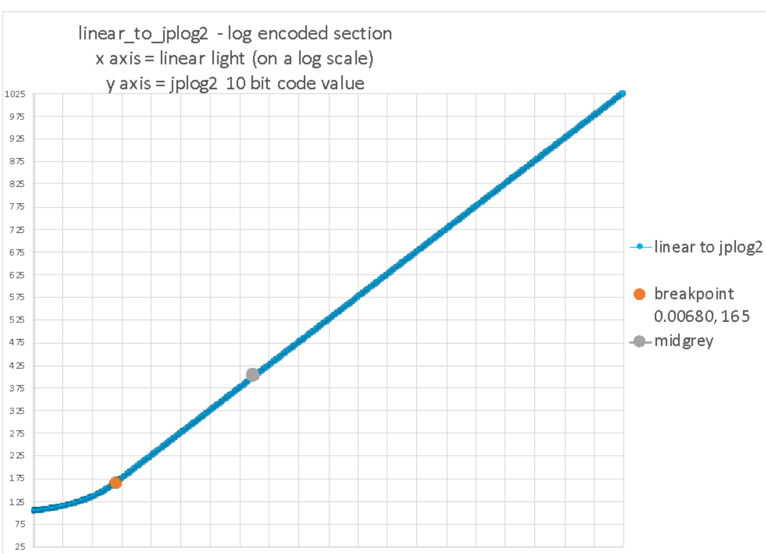
d) Key values in Linear and JPLog2

Linear	JPLog2 (in 10bit_cv)
-0.008756	0
0.0	92.865383
0.18	401.30344
1.0	525
995.99866	1023

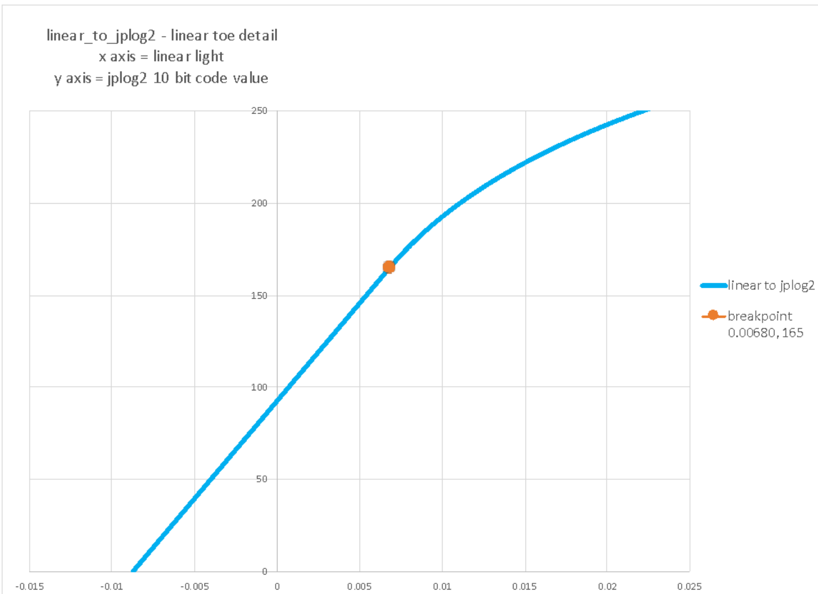
e) Visualizing

We have determined that the most effective way to visualize JPLog2 encoding is by presenting the data in two distinct graphs.

The first graph below illustrates values above the log/linear transition point, with JPLog2 10-bit code values represented on the y-axis and linear relative exposure plotted on the x-axis. The x-axis employs a logarithmic scale to represent the distribution of exposure values better.



The second graph focuses exclusively on the linear portion of the encoding, which lies below the log/linear transition point. In this visualization, JPLog2 10-bit code values are plotted on the y-axis. At the same time, linear relative exposure is mapped on the x-axis using a linear scale to depict the behavior of the encoding in this region accurately.

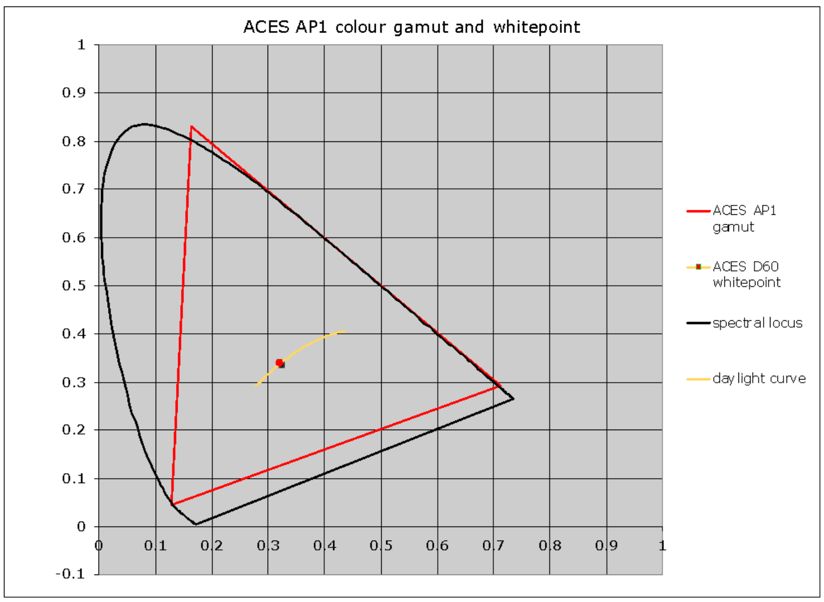


f) Color Space Primaries

For color encoding, we have adopted the ACES AP1 color space as the encoding primaries. ACES AP1 provides a wide gamut optimized for modern color grading and VFX workflows.

Below, we provide a table listing the ACES AP1 primaries and a CIE 1931 xy chromaticity diagram that visually represents their coordinates within the spectral locus.

	x	y
Red	0.713	0.293
Green	0.165	0.830
Blue	0.128	0.044
White	0.32168	0.33767



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- If JPLog2 is used in a networked environment (e.g., cloud-based color processing software), the complete source code of the modified version must be shared with the community.

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- Support and continued development access under agreed-upon licensing terms.

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