SMPTE REGISTERED DISCLOSURE DOCUMENT

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Use of Logarithmic Non-Linear Transfer Characteristic for Transmission of Linear Signals through Limited-Bit-Depth Image Representations and Interfaces

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1 Scope

This document describes a method of connecting the 12-bit linear processing space in an electronic capture camera to a downstream 12-bit linear processing space ("virtual camera processing") via a pair of industry-standard 10-bit serial interfaces carrying 10-bit signal representations. This is achieved by means of a non-linear transfer curve to be applied to the linearly-coded source image signal and a reverse function by means of which the non-linearity may be accurately reversed (forward and reverse lookup tables may also be used as an implementation alternative to the functions). By exploiting both human visual system characteristics and the particular noise characteristics of the camera, the non-linear curve prevents the bit-depth reduction having any perceptible effects on the received image.

By specifying a particular transfer curve and reverse function, interchange between multiple providers and users of source and destination equipment can be achieved.

2 Normative References

SMPTE 274M-2005, Television — 1920 x 1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates

SMPTE 292-2006, 1 Gb/s Signal/Data Serial Interface

SMPTE 372M-2002, Television — Dual Link 292M Interface for 1920 x 1080 Picture Raster

3 Introduction

The signal source employs opto-electronic conversion in R, G, and B color channels that has a linear relationship between input light and output voltage level and has specific noise characteristics. These factors strongly influence the choice of non-linear coding characteristic.

The output voltage delivered to each R, G, or B channel is digitized linearly with 12-bits precision. It is then necessary to transport this linear code space to subsequent processing operations carried out in separate equipment, using an industry-standard interface or interfaces.

The interface to be used is the SMPTE 292 HD serial interface. However, because all processing is to be carried out at a later point, the input to this interface from the camera has not received bandwidth reduction via the mechanism of chroma subsampling ("4:4:4" to "4:2:2" subsampling). The additional bandwidth therefore requires that a pair of SMPTE 292 interfaces be used, with the division of information between the two carried out in accordance with SMPTE 372M.

Representation of the signal to be applied to each interface shall be in accordance with SMPTE 274M, with the exception that the transfer characteristic used shall be as specified in this document.

The choice of the particular non-linear transfer characteristic specified is based on two criteria: recovery of the original linear-coded image with no perceptible losses such as quantizing errors; and utilization of an existing curve already in widespread use in the post-production industry so as to maximize availability for interchange purposes.

4 Linear Source Signal

The output of the analog-to-digital converter attached to each of the three opto-electronic sensors in the camera is specified as:

- linear out, 12-bits representing decimal code values 0 through 4095;
- black level is represented by code value 64;
- sensor maximum output level is represented by code value 3840.

5 Non-Linear Transfer Curve

This is applied to the linear source signal. It is a logarithmic curve equivalent to the industry-standard Cineon curve.

If x is the input and y is the output, then

if x > 37
*then y = floor[500*log(0.02714189*x)+0.5]*
else y = 0

where *floor* is a function that rounds a real number to the nearest integer value, the direction of rounding being towards zero.

NOTE – The image structure document SMPTE 274M referenced by this document specifies that certain codes (000h to 003h, 3FC to 3FFh) are prohibited codes that cannot be transmitted even if they are derived from the conversion formula in §5.

6 Interface

The non-linear signal from Clause 5 shall be transmitted over two interfaces complying with SMPTE 292 (two interfaces are required because the bit rate exceeds the capacity of a single SMPTE 292 interface). The division of codewords between the two 292 interfaces shall be in accordance with SMPTE 372M.

7 Reverse Function

A reverse function converts the 10-bit non-linear values transmitted over the interface back to the linear output values of the 12-bit analog-to-digital converters within the camera.

If x is the input and y is the output, then

$$y=floor[\ 10^{x/500} / 0.02714189 + 0.5]$$

8 Payload Identification

Implementations based on the provisions of this document and executed by the document's proponent use operational context to identify implicitly the nature of the payload (per the provisions of §3).

9 Alternative Use of Look Up Tables

As an alternative to the use of the above functions, conversion between linear and non-linear states may also be obtained by means of forward and reverse lookup tables, respectively. Examples of how the functions may be implemented in a Microsoft Excel spreadsheet are given below.

Forward:

```
=IF     (Nn >37;
        ROUND(500*LOG(0.02714189*Nn);0);
        0)
```

where Nn is the cell number, ranging from 0 through 1023 , containing the LUT input value.

Reverse:

```
=IF     (ROUND(POWER(10;Nn/500)/0.02714189;0)>4095,
        4095;
        ROUND(POWER(10;Nn/500)/0.02714189;0))
```

where Nn is the cell number, ranging from 0 through 4095, containing the LUT input value.