SMPTE ST 2065-3:2012

SMPTE STANDARD

Academy Density Exchange Encoding (ADX) — Encoding Academy Printing Density (APD) Values

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Foreword

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SMPTE ST 2065-3 was prepared by Technology Committee 10E.

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Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

Academy Density Exchange Encoding (ADX) is an encoding of motion picture film color negative and internegative image data as Academy Printing Density (APD) values. ADX values encode image data as the APD printing density values of a color negative film designed to be printed on Kodak Vision® family, Fujifilm Eterna® family, and Fujifilm F-CP® color print films. It is expected that ADX will primarily be used to encode image data represented by the APD printing density values, or an approximation of the APD printing density values, from scanned film. The ADX equations specified in this document provide conversions from APD values to digital code values as 10-bit or 16-bit integer color components. This document also specifies the method for converting between the 16-bit and 10-bit component value encoding metrics.

Most color negative and internegative films require no transformation in order to be compatible with the ADX encoding method, because most color negative and internegative films can be printed onto contemporary motion picture color print films with reasonable results. Color interpositive films are also compatible with the ADX encoding method as they are part of the negative reproduction chain. Some film stocks, such as scan-only color negative film (e.g. Eastman Kodak® 5299) and color print films, were not designed to be printed onto color print films. Printing a scan-only negative or color print film onto a contemporary motion picture color print film is not likely to yield a result that would be considered “good-looking.” Scanned density values from these materials require additional transformation, not covered by this specification, in order to achieve compatibility with the ADX encoding method.

1 Scope

This Standard defines the Academy Density Exchange Encoding (ADX) including the encoding method, the 16-bit and 10-bit component value encoding metrics, and the method for converting between the 16-bit and 10-bit component value encoding metrics.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:”.

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

SMPTE ST 2065-2:2012, Academy Printing Density (APD) — Spectral Responsivities and Reference Measurement Device

4 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

4.1 Academy Density Exchange Encoding (ADX): encoding of motion picture film color negative and internegative image data as APD.

4.2 D_{min}: optical density of an area of a chemically processed photographic medium that has received zero exposure. D_{min} corresponds to the optical density of film base and non-image density due to factors other than exposure to light.

4.3 scan-only color negative film: negative color photographic film primarily designed to be scanned by a motion picture film scanning device rather than printed on any photographic print medium.

4.4 transmittance factor: ratio of the measured flux transmitted by a specimen to the measured flux when the specimen is removed from the sampling aperture of the measuring device.

5 Academy Density Exchange Encoding

5.1 Specification

The ADX equations specified in this section provide conversions from APD values to digital code values as 10-bit or 16-bit integer color components.

5.1.1 Encoding Method

ADX values shall encode image data as the APD values of a color negative film designed to be printed on contemporary motion picture color print films.

Note: Contemporary motion picture color print films include Kodak Vision® family, Fujifilm Eterna® family, and Fujifilm F-CP® color print films.

5.1.2 Encoding Metric

The encoding data metric for the ADX shall be based on D_{min} subtracted APD values. In the equations given below APD_R, APD_G, and APD_B shall represent the red, green, and blue APD values respectively to be encoded. APD_{R_Dmin}, APD_{G_Dmin}, and APD_{B_Dmin} shall represent the red, green, and blue APD values respectively of the assumed or measured D_{min} of the sample.

Note: Printing density values are always non-negative, as a value of 0 represents 100% transmission.

Two component value encodings are specified (ADX_{16} and ADX_{10}).
In ADX_{16} each of the R, G, and B printing density values shall be stored as 16-bit unsigned integers. In ADX_{10} each of the R, G, and B printing density values shall be stored as 10-bit unsigned integers.

The 16-bit component value encoding metric (i.e. ADX_{16}) shall allocate 2 bits of additional range and 4 bits of additional precision as compared to the 10-bit component value encoding metric (i.e. ADX_{10}). The 2 bits of additional range shall be allocated in the most significant bits. The 4 bits of additional precision shall be allocated in the least significant bits. Figure 1 illustrates the allocation of the additional bits in the 16-bit component value encoding metric as compared to the 10-bit component value encoding metric.

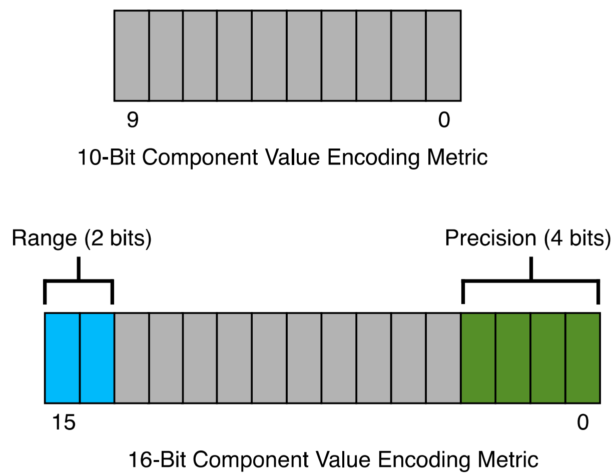

Figure 1 – Bit allocations of ADX_{10} and ADX_{16}

5.1.2.1 ADX_{16} – The 16-bit Component Value Encoding Metric

The ADX 16-bit component value encoding metric shall be known as ADX_{16} or ADX16 where the use of subscripted text is not possible.

ADX_{16} code values shall be 16-bit unsigned integer values. The value range for ADX_{16} shall be [0, 65535].

ADX_{16} code values shall be transformed from APD values using Equation 1. ADX_{16_R}, ADX_{16_G}, and ADX_{16_B} shall represent the red, green, and blue ADX_{16} values respectively.

$$ADX_{16\_R} = \mathrm{MAX}\left[0, \mathrm{MIN}\left[65535, \mathrm{INT}\left[1.00 \times \left(APD_R - APD_{R\_Dmin}\right) \times 8000 + 1520\right]\right]\right]$$
$$ADX_{16\_G} = \mathrm{MAX}\left[0, \mathrm{MIN}\left[65535, \mathrm{INT}\left[0.92 \times \left(APD_G - APD_{G\_Dmin}\right) \times 8000 + 1520\right]\right]\right]$$
$$ADX_{16\_B} = \mathrm{MAX}\left[0, \mathrm{MIN}\left[65535, \mathrm{INT}\left[0.95 \times \left(APD_B - APD_{B\_Dmin}\right) \times 8000 + 1520\right]\right]\right]$$

Equation 1

where the INT operator returns the value of 0 for fractional parts in the range of 0 to .4999… and +1 for fractional parts in the range .5 to .9999…, i.e. it rounds up fractions equal to or greater than 0.5, the MIN(a,b) operator returns the value of a if $a<b$ and b if $a>=b$, and the MAX(a,b) operator returns the value a if $a>b$ and b if $a<=b$.

Note: The quantity ($APD – APD_{Dmin}$) can produce negative values as the D_{min} value of each color layer can vary throughout a scanned roll of film. The offset quantity, 1520, provides a target value for the scanned D_{min}, and allows “footroom” so that densities lower than APD_{Dmin} will be encoded.

5.1.2.2 ADX_{10} – The 10-bit Component Value Encoding Metric

The 10-bit component value encoding metric is specified to provide compatibility with existing hardware. Whenever possible the 16-bit component value encoding metric should be used.

The ADX 10-bit component value encoding metric shall be known as ADX_{10} or ADX10 where the use of subscripted text is not possible.

ADX_{10} code values shall be 10-bit unsigned integer values. The value range for ADX_{10} shall be [0, 1023].

ADX_{10} code values shall be transformed from APD values using Equation 2. ADX_{10_R}, ADX_{10_G}, and ADX_{10_B} represent the red, green, and blue ADX_{10} values respectively.

$$ADX_{10\_R} = \mathrm{MAX}\left[0, \mathrm{MIN}\left[1023, \mathrm{INT}\left[1.00 \times \left(APD_R - APD_{R\_Dmin}\right) \times 500 + 95\right]\right]\right]$$
$$ADX_{10\_G} = \mathrm{MAX}\left[0, \mathrm{MIN}\left[1023, \mathrm{INT}\left[0.92 \times \left(APD_G - APD_{G\_Dmin}\right) \times 500 + 95\right]\right]\right]$$
$$ADX_{10\_B} = \mathrm{MAX}\left[0, \mathrm{MIN}\left[1023, \mathrm{INT}\left[0.95 \times \left(APD_B - APD_{B\_Dmin}\right) \times 500 + 95\right]\right]\right]$$

Equation 2

where the INT operator returns the value of 0 for fractional parts in the range of 0 to .4999… and +1 for fractional parts in the range .5 to .9999…, i.e. it rounds up fractions equal to or greater than 0.5, the MIN(*a,b*) operator returns the value of *a* if $a<b$ and *b* if $a>=b$, and the MAX(*a,b*) operator returns the value a if $a>b$ and *b* if $a<=b$.

Note 1: The quantity ($APD – APD_{Dmin}$) can produce negative values as the D_{min} value of each color layer can vary throughout a scanned roll of film. The offset quantity, 95, provides a target value for the scanned D_{min}, and allows “footroom” so that densities lower than APD_{Dmin} will be encoded.

Note 2: Some motion picture color negative and internegative film products are capable of producing density ranges that exceed the density range capable of being encoded by the 10-bit component value encoding metric.

5.2 Component Value Encoding Metric Conversion

This section specifies the conversions between the 10-bit and 16-bit encoding metrics.

Equation 3 shall be used to convert ADX_{10} values to ADX_{16} values.

$$ADX_{16} = ADX_{10} \times 16$$

Equation 3

Equation 4 shall be used to convert ADX_{16} values to ADX_{10} values.

$$\text{if FLOOR}[ADX_{16} \div 16] \text{ is even}$$
$$ADX_{10} = \left(ADX_{16} + 7\right) \div 16$$
$$\text{if FLOOR}[ADX_{16} \div 16] \text{ is odd}$$
$$ADX_{10} = \left(ADX_{16} + 8\right) \div 16$$

Equation 4

where the value of FLOOR[x] is the largest integer that is not greater than x.

Note: The following is an example C programming language code fragment to convert APD printing density values encoded using the 16-bit component value encoding metric to APD printing density values encoded using the 10-bit component value encoding metric.

```
int ADX16 = …;
int ADX10 = MIN(1023,(ADX16 + 7 + ((ADX16 >> 4) & 1)) >> 4);
```

Annex A Bibliography (Informative)

Academy of Motion Picture Arts and Sciences (A.M.P.A.S.) Specification S-2008-002, Academy Density Exchange Encoding (ADX) and the Spectral Responsivities Defining Academy Printing Density (APD)