



## AN115 – EVD1000/1500 Color Space Conversion: RGB (0...1023) to YCrCb, SMPTE 293

### INTRODUCTION

The EVD1000/1500 has a very flexible digital I/O structure, and in-circuit applications can be configured in a variety of fashions, utilizing different video data formats, levels of user control, etc. In this series of Application Notes, a number of examples of color space conversion are presented, each of which includes a complete set of conversion matrix coefficient register values as required for operation in that particular example mode. For more complete and general application information, please refer to the EVD1000/1500 Data Sheet. The present Application Note describes the method of conversion from input RGB to the internal YCrCb space, e.g., as per SMPTE 293 for RGB in the range (0...1023).

### Color Space Conversion

All internal processing in the EVD1000/1500 is performed in YCrCb mode. Additionally Y values are assumed to be in the range of {64...940}. Cr and Cb values are assumed to be in the range of {64...960}. If RGB data is sent to the EVD1000/1500 an RGB to YCrCb conversion must be performed on the input data before it is processed. If RGB data is required to be output from the chip then an YCrCb to RGB conversion is required to be performed on the processed data before it is sent from the chip. Two independent converters perform the conversions. The coefficients in each converter may be programmed to allow for different relationships between RGB and YCrCb as required for different video standards.

### RGB to YCrCb Conversion

Input color conversion from RGB to YCrCb is enabled whenever the input mode of the EVD1000/1500 is set to RGB. See the Data Sheet for details.

### SMPTE 293, RGB (0...1023)

From the earlier Application Note on SMPTE 293 output conversion, the fundamental relationship between Y, Cr, Cb, R, G, and B is as follows:

$$(101) \quad Y = .299 \times R + .587 \times G + .114 \times B$$

$$(102) \quad Cr = .500 \times R - .418688 \times G - .0813124 \times B$$

$$(103) \quad Cb = -.168736 \times R - .331264 \times G + .500 \times B$$

Where Y,R,G,B {0...1} and Cr,Cb {-0.5...+0.5}



For 10-bit digital implementation  $Y_D$  is in the range {64...940},  $Cr_D$ ,  $Cb_D$  are in the range {64...960} and  $R_D$ ,  $G_D$ ,  $B_D$  are in the range {0...1023}. The above three equations are modified as follows:

$$(104) \quad Y_D = \left( \frac{940 - 64}{1023} \right) \times (.299 \times R_D + .587 \times G_D + .114 \times B_D) + 64 + .5$$

$$(105) \quad Y_D = \frac{262 \times R_D + 515 \times G_D + 100 \times B_D + 66048}{1024}$$

$$(106) \quad Cr_D = \left( \frac{960 - 64}{1023} \right) \times (.500 \times R_D - .418688 \times G_D - .0813124 \times B_D) + 512 + .5$$

$$(107) \quad Cr_D = \frac{448 \times R_D - 375 \times G_D - 73 \times B_D + 524,800}{1024}$$

$$(108) \quad Cb_D = \left( \frac{960 - 64}{1023} \right) \times (-.168736 \times R_D - .331264 \times G_D + .500 \times B_D) + 512 + .5$$

$$(109) \quad Cb_D = \frac{-151 \times R_D - 297 \times G_D + 448 \times B_D + 524,800}{1024}$$

The EVD1000/1500 converts RGB to YCrCb using the following equations:

$$(110) \quad Y_D = \frac{RGB2YCRCB\_KYR \times R_D + RGB2YCRCB\_KYG \times G_D + RGB2YCRCB\_KYB \times B_D + RGB2YCRCB\_KYOFF}{1024}$$

$$(111) \quad Cr_D = \frac{RGB2YCRCB\_KCRR \times R_D + RGB2YCRCB\_KCRG \times G_D + RGB2YCRCB\_KCRB \times B_D + RGB2YCRCB\_KCROFF}{1024}$$

$$(112) \quad Cb_D = \frac{RGB2YCRCB\_KCBR \times R_D + RGB2YCRCB\_KCBG \times G_D + RGB2YCRCB\_KCBB \times B_D + RGB2YCRCB\_KCBOFF}{1024}$$

The following table shows the values that must be written to the registers in the RGB to YCrCb Converter to perform SMPTE 293 RGB to YCrCb Conversion. The values in the top line of each row are signed full width register values (24-bits for registers ending in OFF and 16-bits for other registers). The values in the bottom line of each row are 8-bit width register values. Each full width register is implemented by concatenating two or three 8-bit registers.



<b>Register Assignments SMPTE 293 RGB to YCRCB Conversion, RGB in range from 0 to 1023 (8-bit Registers)</b>	<b>Value (decimal)</b>	<b>Value (HEX)</b>
RGB2YCRCB_KYR (RGB2YCRCB_KYR_HIGH:RGB2YCRCB_KYR_LOW)	262 (1:06)	0106 (01:06)
RGB2YCRCB_KYG (RGB2YCRCB_KYG_HIGH:RGB2YCRCB_KYG_LOW)	515 (2:03)	0203 (02:03)
RGB2YCRCB_KYB (RGB2YCRCB_KYB_HIGH:RGB2YCRCB_KYB_LOW)	100 (0:100)	0064 (00:64)
RGB2YCRCB_KYOFF RGB2YCRCB_KYOFF_HIGH:RGB2YCRCB_KYOFF_MID:RGB2YCRCB_KYOFF_LOW)	66048 (01:02:00)	010200 (01:02:00)
RGB2YCRCB_KCRR (RGB2YCRCB_KCRR_HIGH:RGB2YCRCB_KCRR_LOW)	448 (1:192)	01C0 (01:C0)
RGB2YCRCB_KCRG (RGB2YCRCB_KCRG_HIGH:RGB2YCRCB_KCRG_LOW)	-375 (254:137)	FE89 (FE:89)
RGB2YCRCB_KCRB (RGB2YCRCB_KCRB_HIGH:RGB2YCRCB_KCRB_LOW)	-73 (255:183)	FFB7 (FF:B7)
RGB2YCRCB_KCROFF RGB2YCRCB_KCROFF_HIGH:RGB2YCRCB_KCROFF_MID:RGB2YCRCB_KCROFF_LOW)	524,800 (8:2:0)	080200 (08:02:00)
RGB2YCRCB_KCBR (RGB2YCRCB_KCBR_HIGH:RGB2YCRCB_KCBR_LOW)	-151 (255:105)	FF69 (FF:69)
RGB2YCRCB_KCBG (RGB2YCRCB_KCBG_HIGH:RGB2YCRCB_KCBG_LOW)	-297 (254:215)	FED7 (FE:D7)
RGB2YCRCB_KCBB (RGB2YCRCB_KCBB_HIGH:RGB2YCRCB_KCBB_LOW)	448 (1:192)	01C0 (01:C0)
RGB2YCRCB_KCBOFF RGB2YCRCB_KCBOFF_HIGH:RGB2YCRCB_KCBOFF_MID:RGB2YCRCB_KCBOFF_LOW)	524,800 (8:2:0)	080200 (08:02:00)

For further questions or clarifications, contact your sales representative or the factory for additional support.

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