No. AN9535.1 July 1998

Intersil Digital Signal Processing

Applying the HSP48212 In A Professional Video System

Introduction

This application note discusses methods of applying the HSP48212 Digital Video Mixer (Figure 1) in a professional video system. The digital video mixer outputs a signal that is a weighted sum of two incoming video signals. The functional operation of the HSP48212 is:

$$DOUT = 2 \times [D_{IN}A \times M + D_{IN}B \times (1 - M)] \qquad \text{(EQ. 1)}$$

where $D_{IN}A$ and $D_{IN}B$ are two input video signals with identical input word widths and M is the mix factor which has a value between 0 and 1[1]. The digital video mixer can handle up to 12 bits of data on each input line in either two's complement or unsigned form. The 12-bit mix factor, M, is read on the rising edge of the input clock (CLK) when MIXEN is high. When MIXEN is low, the old value of M is used in Equation 1.

If the HSP48212 is cascaded, the number of bits for D_{OUT} in the intermediate steps should always be one more than the number of bits in $D_{IN}A$ or $D_{IN}B$ to allow for one bit of growth. The output can be rounded in the last digital video mixer stage.

The HSP48212 has an internal delay control word that can be used to delay any of the following for up to 7 CLKs: The RND0-1 round factor, the M0-11 mix factor, the TC input format, the DINA0-11 input data, and the D_{IN}B0-11 input data. The 15-bit delay control word is read in LSB to MSB serially through the DEL pin when 15 clocks are supplied to the LD pin. Delay control allows the inputs to arrive at different times. See Table 1 to relate input signals to DEL bits.

The HSP48212 digital video mixer can be used in professional video systems to do fades, chroma keys, fade-to-blacks, and lap dissolves. The application of the HSP48212 to these four common film and video production techniques is presented in the following sections.

TABLE 1. DELAY CONTROL WORD[1]

SIGNAL NAME	DEL BIT POSITION
RND0-1	12-14
$\overline{TC}$	9-11
M0-11	6-8
DINB0-11	3-5
DINA0-11	0-2

Muxing and Fading Video Streams

In this application, an 8-bit or 10-bit YCbCr color image transmission with separate luma(Y) and chroma (CbCr) components is assumed[2]. For input data less than 12 bits, the least significant bits should be set to 0 to use the fullest range of the HSP48212. Figure 2A shows the most basic schematic for mixing video streams.

The schematic in Figure 2A can be used to multiplex different image signals together by raising MIXEN high and transitioning M from 0 to 1 over 1 or more clocks.

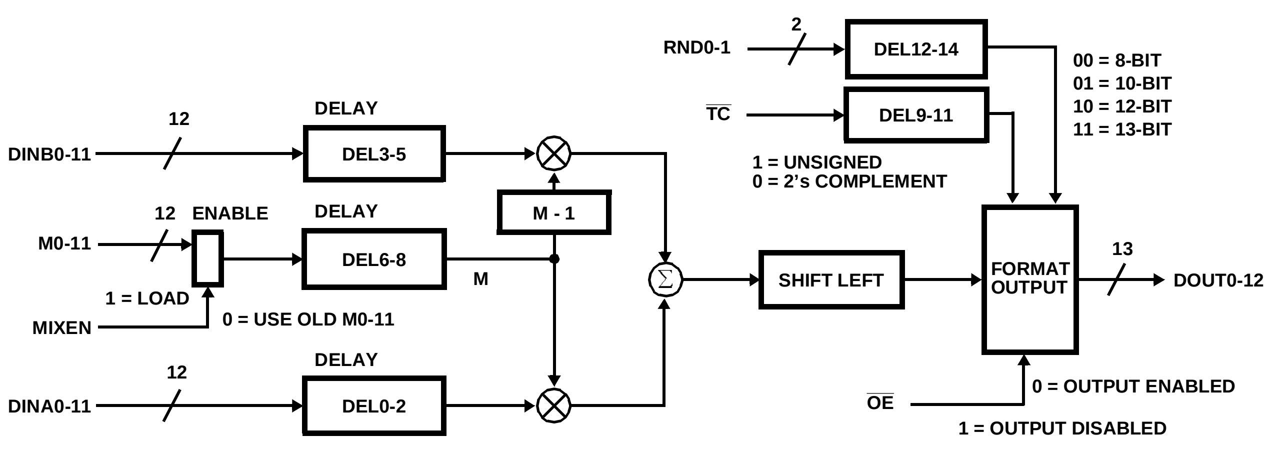


FIGURE 1. BLOCK DIAGRAM OF THE HSP48212 DIGITAL VIDEO MIXER

The diagram in Figure 2A can also be used to fade one image into another. Examples of fading are seen on TV and movies when one scene loses intensity while the next scene gains intensity. In the middle of the transition is the sum of Image 1 and Image 2 at half “strength”. Fading from one image to another requires video streams to both channels in the HSP48212.

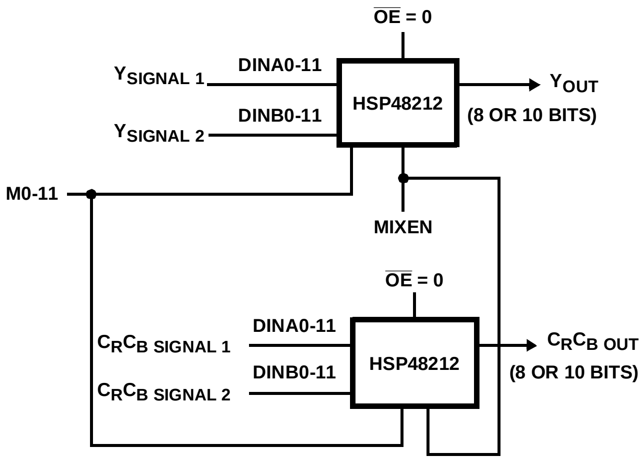


FIGURE 2A. BASIC BLOCK DIAGRAM OF THE FADE APPLICATION

The timing diagram for fading is shown in Figure 2B. The HSP48212 has an initial mix factor M = 1 with MIXEN = 0. To make the transition from Image 1 to Image 2, MIXEN is pulled high, and M is stepped from 1 to 0 over the desired number of CLKs the user wishes the fading effect to occur. During these CLKs, the output image is equal to a weighted sum of Image 1 and Image 2. When M = 0, MIXEN is toggled low, and the output image is equal to Image 2 only. Note that the stepping of M is shown to be a gradual process. In reality, M is a fixed value for each frame, and the transition of M looks more like a stair case. The diagram was drawn to reflect the fact that at high speeds the eye sees what appears to be a gradual decrease in M.

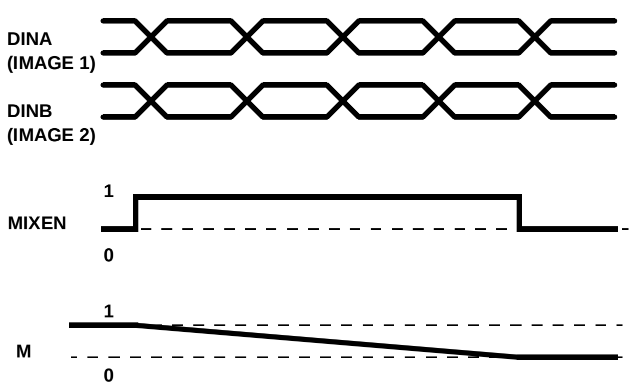


FIGURE 2B. TIMING DIAGRAM OF THE FADE APPLICATION

Fade-to-Black Video Switching

One of the more common scene changing techniques used in TV and movies is called fade-to-black. Visually, one image loses brightness until the screen is blank, or black; then the brightness of a second image increases to full intensity.

The schematic for fade-to-black scene changes is shown in Figure 3A. Initially MIXEN = 0, and Image 1 is the input into DINA. MIXEN is pulled high, and M is stepped from 1 to 0 over a number of CLKs (denoted τ in Figure 3B). When M = 0, the viewer will see a black screen. M remains zero over the number of clocks (denoted ϕ in Figure 3B) the user wishes the viewer to see a black screen. During those ϕ clocks, Image 2 replaces Image 1 as the input into DINA. After ϕ–clocks have passed, M is stepped from 0 to 1 over a number of CLKs. The viewer sees Image 2 emerge from the black screen. When M = 1, MIXEN may be toggled low.

Fade-to-black can be thought of as an extension of fading. Fade-to-black allows both images to be multiplexed onto one channel because the output image never uses both images at the same time. Instead, the output image is equal to a weighted sum of a black screen and either image 1 or image 2 (but not both). Figure 3A shows two physical channels selected by a commutator; the input into DINA0-11 can also be thought of as two multiplexed signals on a single channel. The timing diagram in Figure 3B shows the fade-to-black process.

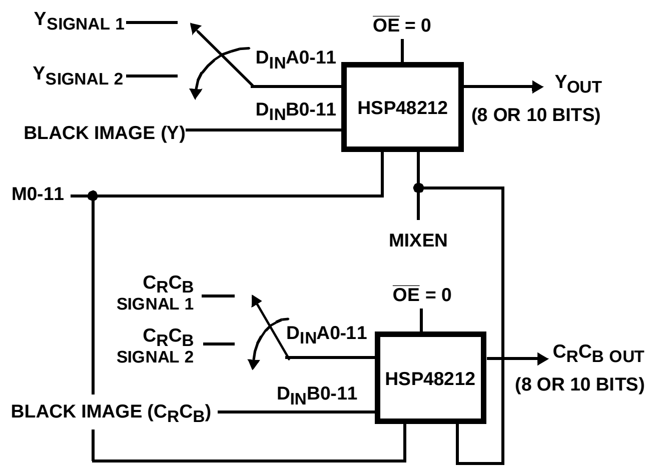


FIGURE 3A. BLOCK DIAGRAM OF THE FADE-TO-BLACK APPLICATION

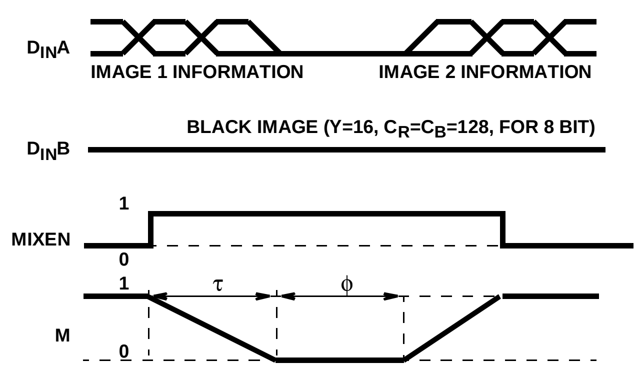


FIGURE 3B. TIMING DIAGRAM OF THE FADE-TO-BLACK APPLICATION

Dissolving Images

The visual effect of the dissolve can be best described in three steps. First, black dots appear in Image 1 at random pixel locations. Second, these dots rapidly grow into black “bubbles” which continue to grow until the Image 1 is replaced by a black screen. Third, the reverse of the latter two occurs; Image 2 “bubbles” out of the black screen. The steps shown in Table 2 demonstrate the logic used to convert Image 1 into a black screen. Turning the black screen into Image 2 involves: 1) changing the DINA input into Image 2 while the screen is still black and 2) following the steps shown in Table 2 with M inverted.

TABLE 2. STEPS FOR DISSOLVING IMAGE 1 INTO IMAGE 2

STEP	INSTRUCTIONS
1	Program delays on both inputs to account for the delay caused by the logic unit. Turn MIXEN high. M = 1 should be used to select Image 1.
2	Randomly generates a set of starting pixel coordinates. When the first frame’s YCbCr data for the selected pixels coordinates arrive, M = 0. M = 1 for all other pixel coordinates.
3	In the next frame, if the Euclidean distance between pixel coordinates and selected pixel coordinates are less than some value b then set M = 0; else M = 1.
4	$\beta = \beta\sigma$, where σ is the growth constant. Go to Step 3 if M is not equal to 0 for all pixel coordinates (i.e., no M = 1 values occur for a whole frame).

Image dissolve is similar to the fade-to-black technique in that Image 1 and Image 2 data can be multiplexed onto a single input line. Thus, the circuit shown in Figure 3A is used in the mixer block shown in Figure 4. The difference between dissolving and fading to black is that the value of M is not a fixed value for each frame. Within each frame, M is chosen to be 1 or 0 for each pixel determined by the logic unit.

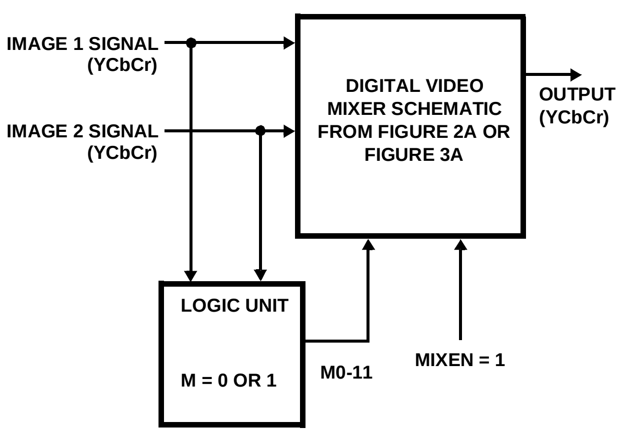


FIGURE 4. APPLICATIONS OF THE HSP48212 REQUIRING A LOGIC UNIT

Chroma Keying Images

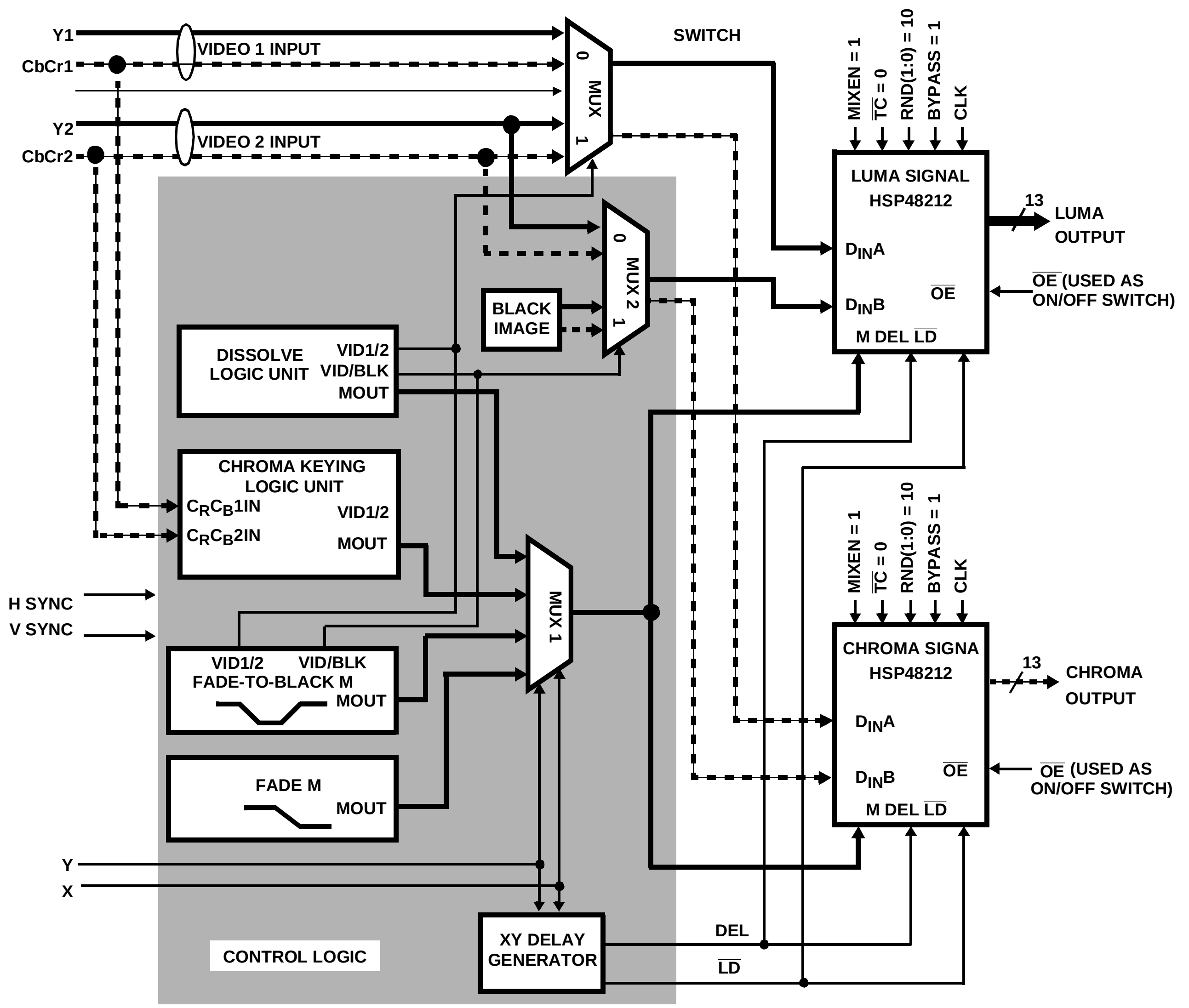
The goal of chroma keying is to graft one object in a scene onto another image. For complicated images, the HSP48212 cannot be used without external delay elements because chroma keying complicated images would require feature extraction techniques with delays much greater than the 7 CLKs. However, the digital video mixer can be used for chroma keying images that have a base color for a background that is different than the object being extracted. For example, brown-suited weathermen standing in front a blue screen can be easily chroma keyed onto computer generated weather maps.

Chroma keying is similar to image dissolve in that the mix factor, M, is either a 1 or 0 determined by a logic unit. Delays must be programmed for the two inputs to account for the time it takes the logic unit to generate the correct M signals. Table 3 gives the steps the logic unit uses to determine M. The output image is equal to a combination of Image 1 and Image 2, requiring the circuit shown in Figure 2A to be used in the mixer block of Figure 4.

TABLE 3. CHROMA KEYING LOGIC

STEP	INSTRUCTIONS
1	Program delays on both inputs to account for the delay caused by the logic unit. Turn MIXEN high.
2	If the C_RC_B data from Image 1 is within some color measure error of the background’s C_RC_B, then M = 0; else M = 1.

For example, if Image 1 is of an object placed in a blue background, the shadow that the object casts will also appear blue with lower brightness, or Y. When the color of a pixel from Image 1 is close to the blue background color, then the output pixel color is set equal to Image 2’s corresponding pixel color. When the color of a pixel from Image 1 is not “close” to the blue background color, then the pixel is assumed to be part of the feature object and the output pixel color is equal to Image 1’s pixel color. Any color measure space that best reflects the way the human eye sees error, such as La*b*, could be used; the root mean square of the XYZ-chromaticity values might be preferred because it doesn’t take brightness into account. The end result is an image with the feature object from Image 1 in the foreground of Image 2. For an example of chroma keying, see High Speed Signal Processing Design Seminar Proceedings[3].



NOTES:

1. The above block diagram is of a device which implements all the imaging techniques discussed in this application note. When OE is enabled, the X and Y mode select will cause the XY Delay Generator to pick the proper delay value for that particular mode and load the delay value into the HSP48212 device by clocking the LD 15 times. After the delay value has been loaded, the device mixed the video signals on Input 1 and Input 2 in the manner specified by the mode.
2. The X and Y serve as mode select. The proper M and inputs into the HSP48212 are done through enables and line selects. When the switch is disabled, the output is equal to the 11 input. If the dissolve and fade-to-black sequences are to take a total of P seconds, then the switch will occur at (P + T)/2 seconds.

FIGURE 5. PROFESSIONAL VIDEO SYSTEM

TABLE 4. CONTROL SIGNALS FOR A PROFESSIONAL VIDEO SYSTEM

X	Y	MODE	DEL
0	0	Fading	0
0	1	Chroma Keying	T1
1	0	Fade-To-Black	0
1	1	Dissolve	T2

NOTE: T1 and T2 are the delay times required to match colors and calculate positions.

Conclusion

The HSP48212 Digital Video Mixer implements a simple function that can be used for complex imaging techniques. The digital video mixer can be used to perform real time scene changing effects such as fading, fading to black and, if the delay associated with those techniques is small, perform difficult video stream changes such as image dissolve. For images that allow simple feature extraction, the HSP48212 can be used for chroma keying. It is possible to design a device that is capable of doing all the techniques mentioned in this application note. A possible diagram for such a device is shown in Figure 5 on the previous page.

References

[1] *HSP48212 Data Sheet,* Intersil.

[2] *K. Jack, "Video Demystified",* HighText Pub. Inc., Solana Beach, CA 92075, 1993.

Sales Office Headquarters

NORTH AMERICA
Intersil Corporation
7585 Irvine Center Drive
Suite 100
Irvine, CA 92618
TEL: (949) 341-7000
FAX: (949) 341-7123

Intersil Corporation
2401 Palm Bay Rd.
Palm Bay, FL 32905
TEL: (321) 724-7000
FAX: (321) 724-7946

EUROPE
Intersil Europe Sarl
Ave. William Graisse, 3
1006 Lausanne
Switzerland
TEL: +41 21 6140560
FAX: +41 21 6140579

ASIA
Intersil Corporation
Unit 1804 18/F Guangdong Water Building
83 Austin Road
TST, Kowloon Hong Kong
TEL: +852 2723 6339
FAX: +852 2730 1433