# Configuring Multiple IPM16 for Cascaded Operation From 4:2:2:4 Streams

## Introduction

IPM16s are systolic image processing arrays capable of performing various operations on digital video and digital images. Alone IPM16s are very powerful, but IPM16s are designed to be cascaded. This application note describes a combination of video effects, filtering, and key generations using three IPM16s and an external FIFO, providing line delays for vertical filtering. Each IPM16 is capable of performing multiple applications in this configuration as illustrated in Figure 1 below.

## Overview

In this configuration, three IPM16s are cascaded to perform a series of operations on multiple streams. In the input block of the first IPM16, the effect generator, three incoming 4:2:2:4 $YC_BC_R$ video streams are converted to the IPM16's internal numeric format for optimal data range and precision. The optimal numeric format is also used to communicate data streams between IPM16s. The output block of the IPM16s can redirect streams to subsequent IPM16s in various time-multiplexed formats for flexible application designs. Timing signals are used as internal reference and to equalize the video streams.

A configuration is pre-loaded into each IPM16. The configuration can be changed depending upon the desired effect. Once a configuration is loaded, changes to control parameters such as wipe size, blend ratio, filter coefficients, and keying parameters are made during the vertical blanking interval to guarantee smooth transitions.

The three IPM16s are configured as effect generator, filter, and DSK/blender/switcher respectively. The effect generator applies various effects on input video streams and creates an alpha channel that carries wipe patterns. Filters are then applied to selected video streams and alpha channels. Processed streams are combined to produce the output streams by multiple blending, switching, and keying operations. Several applications have been described in detail in previous Application Notes 1 through 5. This application note demonstrates how to combine individual applications and build them into a large system.

## Efficiency

Several applications, each taking part of an IPM16 configuration, share the IPM16 for most efficient usage. Because of the IPM16's flexible routing structure, applications can be designed to fill the processing core without wasting any resources. For applications with similar operations, a general design is used such that multiple applications can be covered by a single configuration. Considerations for smooth transitions between applications are also included in the configuration.

## Block Diagram

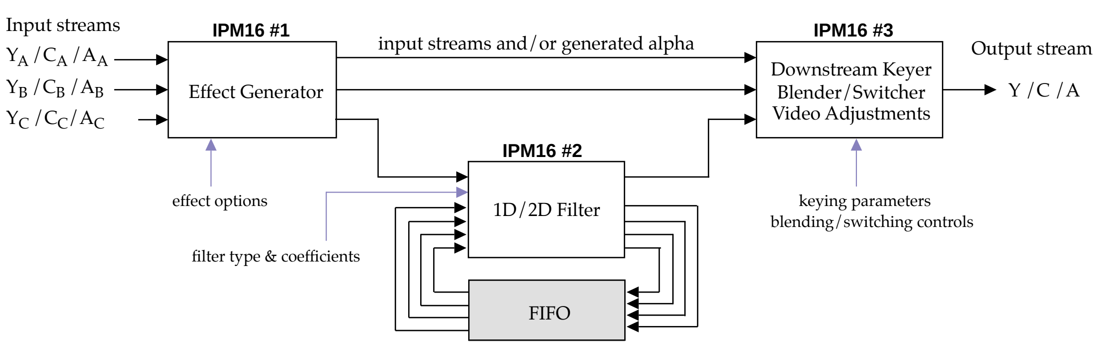


Figure 1: Block diagram for three IPM16 and a FIFO

## *First IPM16*

The first IPM16 is used to create an alpha channel that carries wipe patterns to other IPM16s and generates effects for luma and chroma components in part of the configuration. Operations performed in this IPM16 are:

- **Standard and Noise Wipe Pattern Generation**

  The IPM16 produces hard, soft, and bordered wipe patterns by dynamically calculating the alpha value from wipe parameters and current pixel positions. Motion effects such as tumbling, revolving, scaling, or radial wipes are achieved by changing wipe parameters during the vertical blanking. Wipe patterns can be modulated with time-varying sine waves in any specified direction. Wipes are replicated in horizontal and vertical directions for alternating or checkerboard patterns. Besides standard wipe patterns, noise patterns can be created from internally generated synchronous random numbers. More details about wipes and their IPM16 configurations can be found in Application Note 5 “Generating Wipes using the IMP16”

- **Region Definition**

  Besides wipe effects, generated patterns can be used to define regions for further filtering, keying, and video adjustments. An example of dynamically generating filter coefficients from soft edge patterns can be found in Application Note 7 “Generating Filter Coefficients from Alpha Using an IMP16”.

- **Color Replacement**

  The IPM16 compares chroma data with adjustable color ranges and replaces data that is in the ranges with other colors. The replacement colors can be derived from original colors or constant colors. Different color ranges may be applied to $C_B$ and $C_R$ components.

- **Posterization / Solarization**

  Luma/chroma data can be properly rounded and truncated to any specified bit depth as needed for posterization/solarization.

## *Second IPM16*

The second IPM16 applies one or two-dimensional filters on selected video streams. For vertical filters, the external FIFO takes unfiltered streams, produces line delays, and sends data back to the IPM16 such that multiple lines can be filtered in the processing core. The IPM16 filter configuration consists of a general purpose two-dimensional filter which can be used as an one-dimensional horizontal or vertical filter. The two-dimension filter operates as either a 5x5 filter on one video stream’s luma and chroma components or two 3x3 filters on two video streams.

Folding can be performed in vertical, horizontal, or diagonal directions to reduce the number of multiplications in the processing core. Examples for filters with various folding methods are shown in Figure 2. Current and delayed pixels are added/subtracted together and multiplied by a single coefficient in an arithmetic unit. The configuration for horizontal and vertical folding can be found in Application Note 1 “Configuring IPM16 for 4:2:2:4 to 4:4:4:4 Conversion from a 601 Stream” and Application Note 4 “Configuring IPM16 for 2-Dimensional Filtering”. Configuration for diagonal folding is similar to vertical folding with some additional routing changes.

| | | |
|---|---|---|
| -1 | -1 | -1 |
| -1 | 8 | -1 |
| -1 | -1 | -1 |

| | | |
|---|---|---|
| -1 | 0 | 1 |
| -2 | 0 | 2 |
| -1 | 0 | 1 |

| | | |
|---|---|---|
| -1 | -2 | -1 |
| 0 | 0 | 0 |
| 1 | 2 | 1 |

| | | |
|---|---|---|
| -2 | -1 | 0 |
| -1 | 0 | 1 |
| 0 | 1 | 2 |

Figure 2: Filters with various folding types

Since the processing core performs two operations in a pixel clock, luma and chroma components can share the same arithmetic units for efficient implementation. The processing core is also capable of performing two independent computations on even and odd pixel clocks such that time-multiplexed $C_B$ and $C_R$ components can be set with different filter coefficients. Alpha can be redirected to filters by changing the routing registers between the input interface and the IPM16’s processing core.

- **Softening or Sharpening**

  Softened or sharpened outputs are produced by a user-supplied two-dimensional filter before being blended into the final output.

- **Noise Reduction**

  A band-width limited filter is applied to reduce the high frequency noise.

**INTELLIGENT PARADIGM**
10050 N. Wolfe Road, SW2-152 • Cupertino, CA U.S.A. 95014-2528
Tel: 408-725-3810 • Fax: 408-725-3819
www.IntelligentParadigm.com




Version: 1.1 April 2000

- **Anti-Flicker**

  A vertical filter is applied to both even and odd fields of a video source to smooth the motion artifacts shown on interlaced displays.

- **Emboss For Logo Generation**

  Static and animated logos based on pre-rendered graphics are common on today's video programs. The IPM16 can blend a video stream from pre-rendered graphics with alpha but it can also generate a dynamic logo from a video stream by using an emboss filter to create shadows and outlines for the logo. The alpha mask is then combined with the program video in the downstream keyer. Contrast between shadow and video is adjusted by an arithmetic unit. Luma and chroma data can be processed with the alpha in the filter for a shifted transparent logo.

## Third IPM16

The third IPM16 combines processed streams and alphas generated from other IPM16s. Adjustments and inversions can be performed either before or after combination as needed. Operations in this IPM16 include:

- **Downstream Keying (DSK)**

  The downstream keyer takes either pre-rendered graphics or embossed logo and mixes with input video streams based on an alpha or a constant parameter. The logo can be dynamically adjusted to accommodate varying backgrounds.

- **Chroma and Luma Keying**

  Luma and chroma values can be used to overlay one video over another with adjustable control parameters. Broadcast quality chroma keys can be implemented in part of a single IPM16 configuration.

- **Multi-Layer Blends, Switches, and Fades**

  The IPM16 can composite multiple video streams based on each stream's alpha value as described in Application Note 3 "Configuring an IPM16 For Multiple Layer Compositing From 4:4:4:4 Streams".

- **Wipe Effects**

  Wipe patterns are created in the effect generator and blended with video streams in the third IPM16 through an alpha channel. Various border types and colors are produced simultaneously with blending computation for optimal implementation.

- **Noise Dissolves and Wipes**

  The IPM16 internally generated random numbers are processed with dissolve parameters in the effect generator and then sent to the third IPM16 for blending two video streams with the specified blending ratio, which can change over time to achieve dissolve effects.

- **Video Adjustments**

  Commonly used operations such as brightness, contrast, hue, and saturation adjustments can be made on individual input video streams before blending or on the final output video. Alpha's level, gain, and inversion can also be performed.

## Results

This application note described various effect generation, filtering, blending, switching and keying applications in a three IPM16 configuration. Multiple applications can be applied to video streams with real-time user controls. IPM16s can switch applications in a generalized configuration. Graphical results for various combinations of multiple applications are shown in Figure 3.

Figure 3 (a) through 3 (d) shows three inputs for the configuration, with Figure 3 (d) being the alpha of the graphics. Figure 3 (e) shows posterization on one input video stream. Two video streams are blended together with generated wipe pattern and then keyed with embossed logo. Figure 3 (f) shows a color replaced video stream bounded by another input video with a modulated ellipse wipe. The luma and chroma components are also processed by filters such that pixels are shifted inside the embossed transparent logo. Figure 3 (g) shows blending of both original and filtered video streams of the same source with a circle wipe pattern. Figure 3 (h) shows blending of two video streams based on the third video stream, which can be either luma, chroma or alpha blends. Three different border types are illustrated in Figure 3 (e) through 3 (g): hard-colored, soft-colored, and soft borders.



**INTELLIGENT PARADIGM**
10050 N. Wolfe Road, SW2-152 • Cupertino, CA U.S.A. 95014-2528
Tel: 408-725-3810 • Fax: 408-725-3819
www.IntelligentParadigm.com

(a) A input

(b) B input


(c) C input


(d) Alpha of C input


(e) Wipe on posterized A and input B;
keyed with embossed C


(f) Modulated wipe on A and color converted B;
keyed with embossed transparent C


(g) Input A blended with brightened blurred A
based on a soft circle wipe pattern,
then keyed with C

(h) Input A blended with brightened B
based on C stream's alpha

Figure 3: Inputs and results of the three IPM16 configuration

***INTELLIGENT PARADIGM***
10050 N. Wolfe Road, SW2-152 • Cupertino, CA U.S.A. 95014-2528
Tel: 408-725-3810 • Fax: 408-725-3819
www.IntelligentParadigm.com




Version: 1.1 April 2000