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Configuring IPM16 For Multiple Layer Compositing From 4:4:4:4 Streams

Introduction

The IPM16 is a systolic image processing array capable of performing various operations on digital video and digital images. This application note describes multiple layer compositing from 4:4:4:4 streams using a portion of an IPM16. An example of three layer compositing using RGB source streams is discussed in detail. This configuration can be generalized to composite more than three layers from various video sources. The IPM16 is also capable of composite YC_BC_R streams in a similar method.

Overview

The input interface pre-processes incoming streams to the IPM16 internal format and sends data streams to the processing array. Since the IPM16 is also capable of other processes such as interpolation and color space conversions (see application notes of these subjects), part of the IPM16 may perform these conversions prior to compositing as needed. The internal data is then transformed by the routing to accommodate the optimal compositing design. Data of multiple layers are computed in the processing unit and the result is re-equalized with timing signals at the output interface.

The IPM16 can be cascaded to composite an arbitrary number of layers. In a cascaded configuration, the output 4:4:4:4 stream from an IPM16 is directed to the next IPM16 and processed with other video sources.

Routing

The routing between the input interface and the processing array extracts a portion of data from multiplexed streams and re-directs the data to another stream. This provides flexibility for various application designs. An optimal time-division multiplexed format is chosen as the internal format for compositing.

Configurations of the Processing Unit

The processing unit performs four tasks:

- Computes the multiplication factors from alpha of current layer and previous layers
- Multiplies the factor with RGB components for intermediate results
- Sums the intermediate RGB results of multiple layers
- Sums the multiplication factors to obtain output alpha for further compositing

Figure 2 on the back shows configurations for the first two steps. Foreground is G1/B1/A1/R1. Alpha components are used for green in the same arithmetic units and are sent down to other arithmetic units for blue and red calculations. The configuration is stackable to allow more layers in the compositing scheme. For the current three layer compositing, the alpha for background (A3) has value one and is not used in computation.

Block Diagram

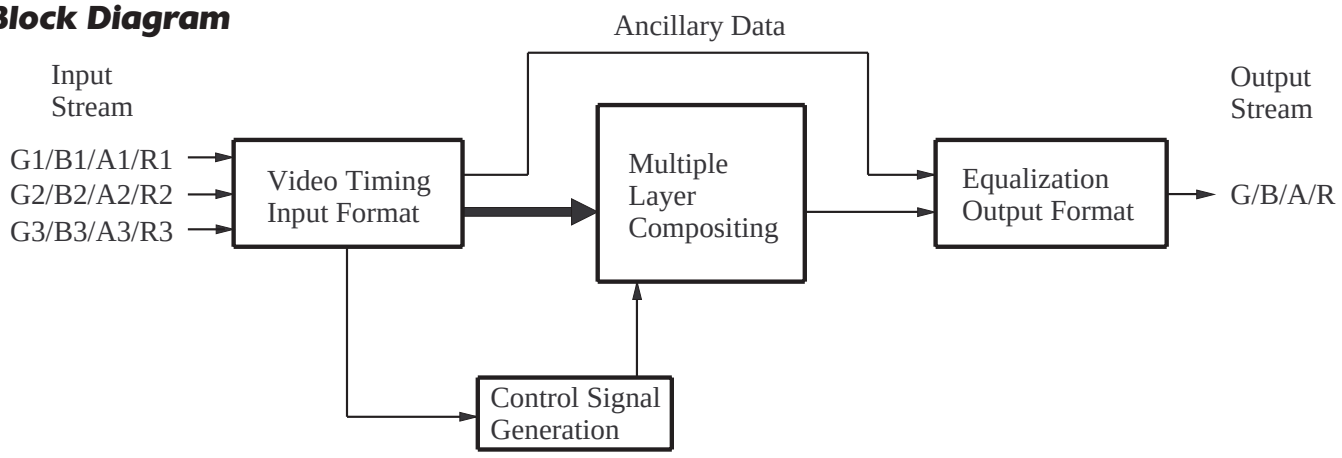

Figure 1: Block Diagram for three layer compositing inside the IPM16

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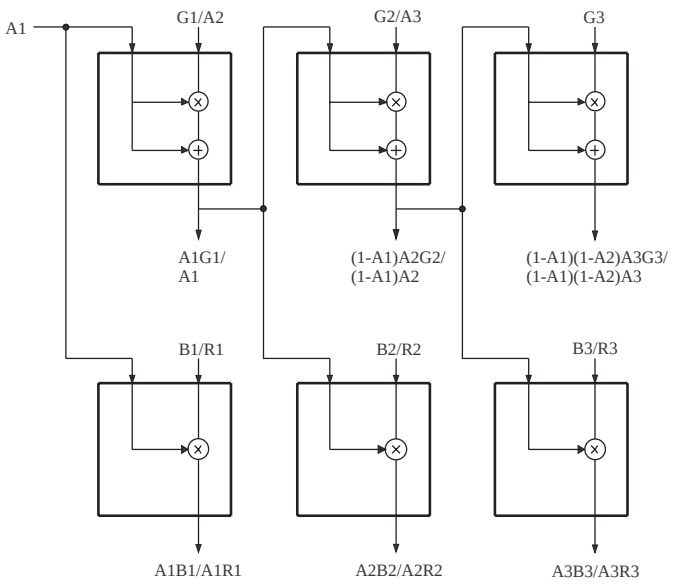

Figure 2: Arithmetic unit compositing for three layer compositing

Derivations

A general equation for output green component is:

G = A1G1 + (1-A1)A2G2 + (1-A1)(1-A2)A3G3 + (1-A1)(1-A2)(1-A3)A4G4 + (1-A1)(1-A2)(1-A3)(1-A4)A5G5 + ...

The IPM16 uses reduced equations to achieve higher efficiency. For the current three layer example, the reduced equations are:

G = c1 G1 + c2G2 + c3G3,
with c1 = A1, c2 = A2 (1-c1), c3 = A3 (1-c1-c2)

Only five multiplications are needed in the reduced equations instead of six in the original equation for the three layer example. As the number of layers increases, the amount of multiplications decreases significantly in the reduced equations.

Compositing Efficiency

Besides implementing efficient equations in the IPM16, the design also includes other methods to increase the efficiency. First, a time-division multiplexed data format is used in the IPM16 processing array for 2x operation. In the arithmetic units, a multiplier performs two multiplications on different components during one pixel clock.

The computation for multiplication factors is decomposed into several stages. These stages may be implemented in different places to fully utilize multipliers. Processed values are sent to other arithmetic units for computing multiplication factors of subsequent layers.

I/O Streams

The 4:4:4:4 time-division multiplexed data arrives at the input interface every 1x pixel clock. Each component, in the order of G, B, A, R, occupies a quarter of an 1x pixel clock. Each internal stream carries two components alternately on even and odd phases of a pixel clock for 2x processing. For the background, the green component occupying even phases of a stream is shown as "internal G/X stream" in Figure 3 below. The output interface recovers 4:4:4:4 time-division multiplexed data from composited G/A and B/R streams.

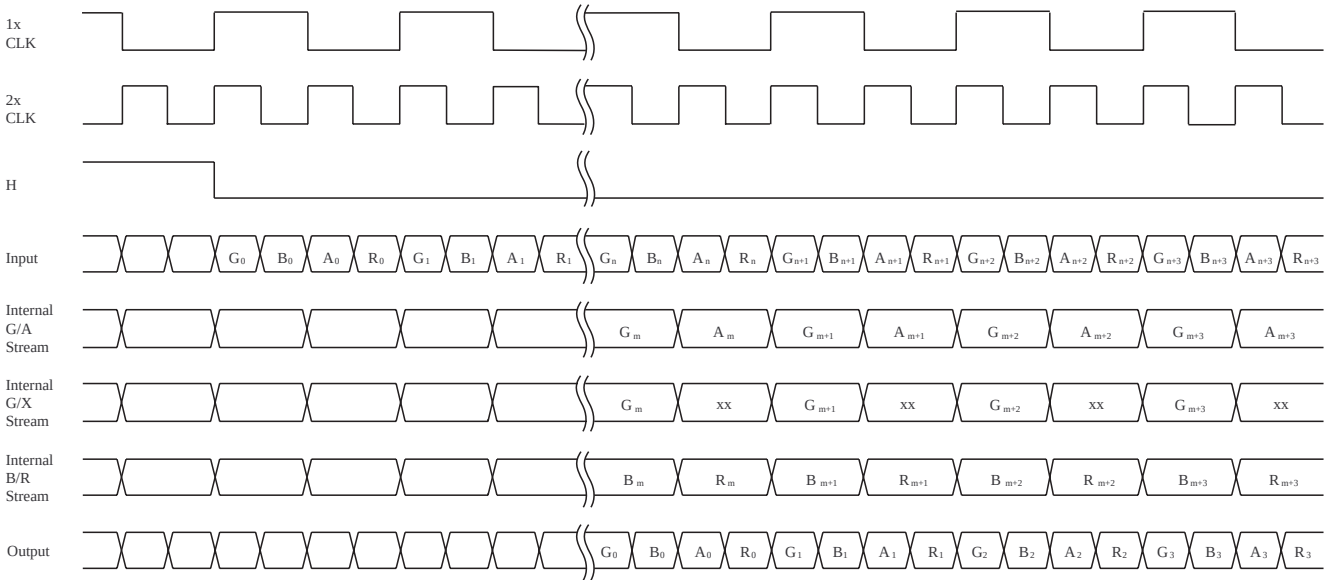

Figure 3: Data streams in the compositing process

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