CS6400
Color Space Converters

AMPHION™
Virtual Components for the Converging World

The CS6400 series of color space converters are virtual component solutions for leading-edge image processing applications. Capable of sustained data rates of over 180 mega-conversions/sec in an ASIC implementation and 95 mega-conversions/sec in FPGA, these color space converters are ideally matched to Amphion's other imaging products such as the CS6100 series of JPEG products as part of a complete image processing system. The CS6400 products are available in both ASIC and programmable logic versions that have been handcrafted by Amphion to deliver high performance with low-power and minimal silicon area.

COLOR SPACE CONVERSION

RGB is the standard color format for most digital video input and output devices, such as display monitors. However, processing an image in the RGB color space, including operations such as sub-sampling and compression, is frequently not the most efficient method. To speed up some processing steps many broadcast, video and imaging standards (PAL/NTSC) use luminance and color difference video signals, such as YUV, making a mechanism for converting between formats necessary.
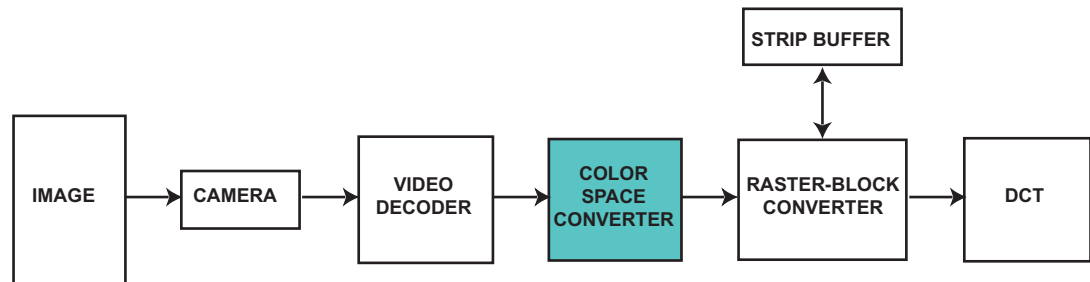

Figure 1: Typical Digital Video Decoding Channel Containing CS6400

FEATURES

♦ **Converts television broadcast signal colors to digital video colors (CS6411 and CS6421) or digital video colors to broadcast signal colors (CS6410 and CS6420)**
♦ **Available for SoC, ASIC and FPGA**
♦ **Internal precision coefficient width of 10 bits**
♦ **One conversion every clock cycle**
♦ **Low latency - 3 clock cycles**

APPLICATIONS

♦ **Video output conversion to digital RGB**
♦ **Image filtering**
♦ **Machine vision**
♦ **Video and still image processing**

KEY METRICS AND SPECIFICATIONS

Refer to Table 4 for details of metrics for the CS6400 series of color space converter cores.

CS6400 SYMBOL AND PIN DESCRIPTION

A representative symbol, with the signal names, is shown in Figure 2.

Unless otherwise stated all signals are active high and bit(0) is the least significant bit.
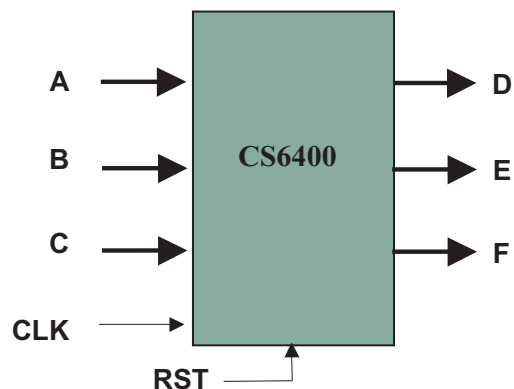
Table 1 summarizes the signal functions.

Figure 2: Core Schematic

Table 1: I/O Descriptions

Signal	I/O	Description			
		CS6410	CS6411	CS6420	CS6421
Clk	I	Core Clock, clock input			
Reset	I	Core reset, Asynchronous reset that resets all registers to zero			
A	I	Red color[7:0]	Luminance[7:0]	Red color[7:0]	Luminance[7:0]
B	I	Green color[7:0]	U color difference data[7:0]	Green color[7:0]	Chroma red data[7:0]
C	I	Blue color[7:0]	V color difference data[8:0]	Blue color[7:0]	Chroma blue data[7:0]
D	O	Luminance[7:0]	Red color[7:0]	Luminance[7:0]	Red color[7:0]
E	O	U color difference data[7:0]	Green color[7:0]	Chroma red data[7:0]	Green color[7:0]
Fb	O	V color difference data[8:0]	Blue color[7:0]	Chroma blue data[7:0]	Blue color[7:0]

General Description

The CS6400 color space converters perform linear transformations from one color space to another. Table 1 shows the members which make up the CS6400 family of products. All members of the 6400 product family use 10-bit coefficients in the core for all calculations with rounding carried out at the outputs. All cores have both input and output registers plus an additional pipeline cut allowing high speeds to be achieved with a low latency of 3 clock cycles and a throughput of 1 clock per cycle.

Figure 3 shows the internal operation of a generic converter. Internal precision of 10 bits maintains accuracy of the 8 bit output. Input and output colors as well as specific coefficient values are given in Table 3.

Table 2: 6400 Family of Cores

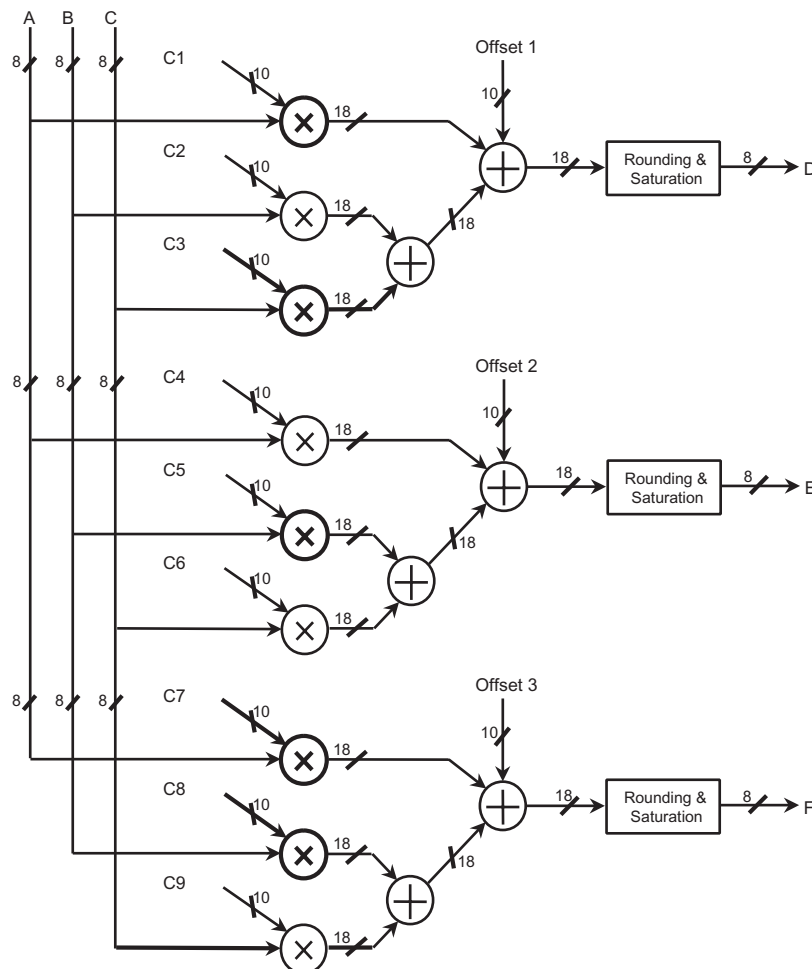| Product	Input Format	Output Format
CS6410	RGB	YUV
CS6411	YUV	RGB
CS6420	RGB	YCrCb
CS6421	YCrCb	RGB

Figure 3: Block diagram of generic color space converter

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Table 3: Input and output colors with specific coefficient values

I/O	CS6410	CS6411	CS6420	CS6421
Color A	R	Y	R	Y
Color B	G	U	G	Cr
Color C	B	V	B	Cb
Color D	Y	R	Y	R
Color E	U	G	Cr	G
Color F	V	B	Cb	B
C1	0.299	1.140	0.257	1.164
C2	0.587	0	0.504	1.596
C3	0.114	1.140	0.098	0
Offset 1	0	0	16	-223
C4	-0.147	1	0.439	1.164
C5	-0.289	-0.394	-0.368	-0.813
C6	0.436	-0.581	-0.071	-0.392
Offset 2	0	0	128	136
C7	0.615	1	-0.148	1.164
C8	-0.515	-2.032	-0.291	0
C9	-0.100	0	0.439	2.017
Offset 3	0	0	128	-277

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TIMING DIAGRAMS

Figure 4 demonstrates only the functional timing for the core operation. A latency of 3 clock cycles can be observed.
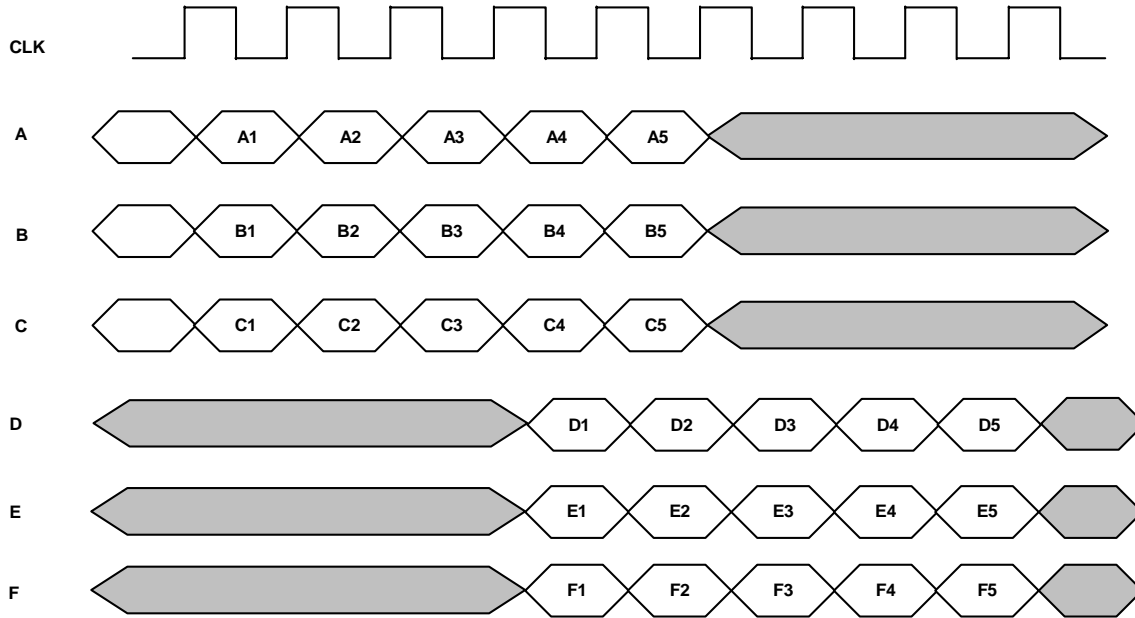

Figure 4: Generic CS6400 Timing Diagram

AVAILABILITY AND IMPLEMENTATION INFORMATION

ASIC CORES

For applications that require the high performance, low cost and high integration of an ASIC, Amphion delivers a series of multimedia ASVCs that are pre-optimized by Amphion experts to a targeted silicon technology. Choose from off-the-shelf versions of the CS6400 family available for many popular ASIC and foundry silicon supplier technologies or Amphion can port the CS6400 to a technology of your choice.

FROGRAMMABLE LOGIC CORES

For ASIC prototyping or for projects requiring the fast time to market of a programmable logic solution, Amphion provide programmable logic cores that offer the silicon-aware performance tuning found in all Amphion products, combined with the rapid design times offered by today's leading programmable logic solutions.

Table 4: CS6400 Cores - Key Metrics

Product	Performance	Spartan™-II	Virtex™	Virtex™-E	Virtex™-2
CS6410	Area / Slices	222	222	222	222
	Fmax / MHz	80	75	100	115
CS6411	Area / Slices	140	140	140	140
	Fmax / MHz	65	75	90	105
CS6420	Area / Slices	204	204	204	204
	Fmax / MHz	65	65	90	90
CS6421	Area / Slices	179	179	179	179
	Fmax / MHz	65	75	95	105

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ABOUT AMPHION

Amphion (formerly Integrated Silicon Systems) is the leading supplier of speech coding, video/ image processing and channel coding ASVCs for system-on-a-chip (SoC) solutions in the telecommunications/ Internet, consumer / communications and wireless markets.

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