TVP5160 3DYC Operation

1 Introduction

The TVP5160 provides 3DYC functionality for both NTSC and PAL. This feature builds on the existing 2D 5-line comb filter and is designed to reduce the dot crawl and false color in composite video inputs by storing and processing multiple frames. By using multiple frames, the advantage of 3DYC is best seen on static images or areas within video where the scene has no motion. With areas of motion, the 2D comb filter is used; in still areas, the 3DYC is used.

2 Modes of Operation and Memory Requirements

3DYC may operate independently or concurrently with 3DNR. The various modes of operation for the 3DNR and 3DYC are listed in Table 1.

Table 1. 3DYC and 3DNR Modes of Operation

Mode	Operation	Memory Required
Mode 0	3DYC + 3DNR	4MB
Mode 1	3DYC only	2MB
Mode 2	2D 5-line CF + 3DNR	2MB
Mode 3	2D 5-line CF only (default)	None

3 Technology Overview

3DYC works in parallel with the 2D comb filter based on the user settings and the level of motion detected in the video. Motion is detected by comparison of luma and chroma from three frames of the input composite signal. The frame differences are converted to absolute numbers, and a threshold is subtracted from this absolute value. The resultant difference is limited to a lower limit, gained up, and limited to an upper limit. The lower limit is indicative of 3D comb output and the upper limit is indicative of 2D comb output. The output is termed Km. Figure 1 shows this process.

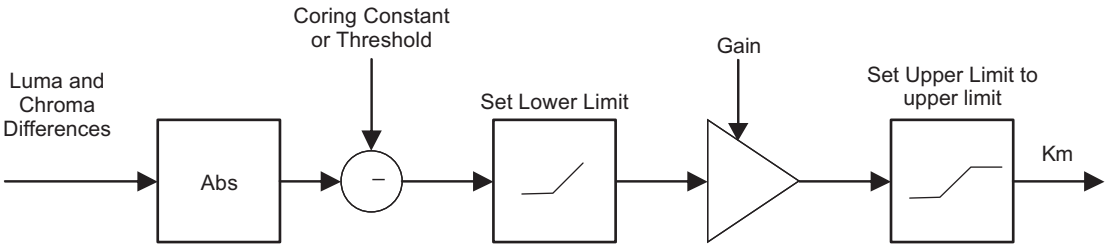

Figure 1. 3DYC Motion Detection

If the frame differences are large, Km saturates to the upper limit and 2D comb is output. If the frame differences are smaller than the threshold, 3D comb is output. If the frame differences are such that a Km between the upper and lower limits occurs, 2D and 3D comb are mixed proportional to Km. This provides for a smooth transition between 2D and 3D comb outputs.Figure 2 shows the transfer function.

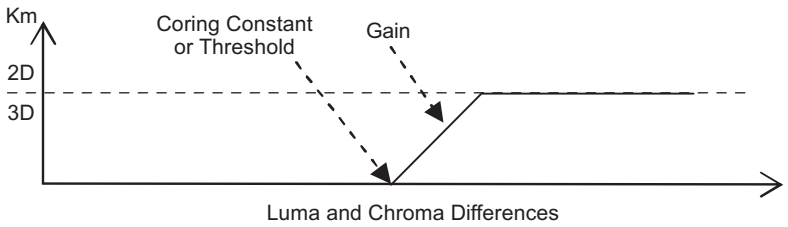

Figure 2. Transfer Function

4 Configuring the SDRAM Controller

The SDRAM controller of the TVP5160 must be properly initialized before enabling 3DYC. This is to ensure the SDRAM controller is configured for the memory size used.

Table 2 shows the SDRAM Control register used to configure the SDRAM controller. The bit definitions are also provided. Typically, only the Configuration and the Enable bits need to be set to configure the SDRAM controller. The SDCLK Delay Control has been optimized by default for most SDRAM parts.

After the SDRAM controller is properly configured, 3DYC may be enabled by setting the Chrominance Processing Control 1 Register (0x0D) to 0x80.

Table 2. SDRAM Control Register – 0x59

7	6	5	4	3	2	1	0
Reserved	**SDCLK Delay Control**				**Enable**	**Configuration**	

Configuration [1:0]

Bit1	Bit0	Arrangement
0	0	2 banks x 2048 rows x 256 columns 16Mbits
0	1	4 banks x 2048 rows x 256 columns 32Mbits
1	0	2 banks x 4096 rows x 256 columns 32Mbits
1	1	4 banks x 4096 rows x 256 columns 64Mbits

SDRAM with more rows, columns and/or banks can be used as long as the minimum requirements are met. Additional rows, columns and/or banks will be ignored and unused by the memory controller.

Enable

0	SDRAM controller disabled (default)
1	SDRAM controller enabled

SDCLK Delay Control [3:0]

Bit3	Bit2	Bit1	Bit0	Delay
0	0	0	0	Default
0	0	0	1	0.58 ns
1	0	1	1	6 ns
1	1	1	1	9.3 ns

This register changes the delay from the default position of SDCLK in increments of approximately 0.58 ns.

5 3DYC I²C Registers

Table 3 lists the I²C registers which control 3DYC.

Table 3. I²C Registers for 3DYC

Register Name	Address	Default	Description	R/W
Chrominance Processing Control 1 Register	0Dh	00h	Bit 7 enables 3DYC	R/W
3DYC Luma Coring LSB	84h	80h	Y coring limit LSB	R/W
3DYC Chroma Coring LSB	85h	80h	UV coring limit LSB	R/W
3DYC Chroma/Luma Coring MSB	86h	80h	UV/Y coring limit MSB	
3DYC Luma Gain	87h	80h	Y gain	R/W
3DYC Chroma Gain	88h	40h	UV gain	R/W
3DYC Signal Quality Gain	89h	80h	Signal quality gain	R/W
3DYC Signal Quality Coring LSB	8Ah		Signal quality coring LSB	R
3DYC Signal Quality Coring MSB	8Bh		Signal quality coring MSB	R

The following sections explain how to change the 3DYC motion detection settings. These settings can be manipulated to provide an optimal 2D/3D threshold setting of the TVP5160 comb filter.

5.1 3DYC Luma and Chroma Coring Registers (84h to 86h)

The coring constant and gain are user settable through I²C. Luma or chroma difference smaller than the value set for coring constant or threshold is assumed to be noise, resulting in the pixel to be recognized as 'no motion' or 'still picture'. This results in the generated Km to indicate the application of intraframe (3D) comb.

Application of 3D comb considerably increases the clarity of still or static portions of the picture. If the threshold is increased, there is more chance that the 3D comb will be applied. If a large value is used for the threshold, 3D comb is applied even where there is motion, which can result in chroma and luma artifacts in areas of motion.

If a small value is used for the threshold, there is more chance that the 2D comb will be applied, which can show chroma and luma artifacts in still or static portions of the picture. The user can arrive at a suitable tradeoff in chroma and luma artifacts in motion and still areas by adjusting the threshold value.

The default values have been set using a wide variety of test patterns and are expected to be close to the optimal value. Using the minimum value for the thresholds results in a high probability the 2D comb will be applied to the entire picture.

5.1.1 Luma Coring

The Luma Coring register is a 10-bit register that controls the coring level for inter-frame luma difference. A difference smaller than the set value is assumed to be noise, resulting in the pixel to be recognized as 'no motion' or 'still picture', favoring intra-frame (3D) comb output. The minimum value of x000 favors 2D comb output, and the maximum value of x3FF favors 3D comb output.

5.1.2 Chroma Coring

The Chroma Coring register is a 10-bit register that controls the coring level for inter-frame chroma difference. A difference smaller than the set value is assumed to be noise, resulting in the pixel to be recognized as 'no motion' or 'still picture', favoring intra-frame (3D) comb output. The minimum value of x000 favors 2D comb output, and the maximum value of x3FF favors 3D comb output.

5.2 3DYC Luma and Chroma Gain Registers (87h, 88h)

Gain controls how large a chroma or luma difference will force a 2D comb to be applied. If the gain is reduced, more input differences produce a value of Km that causes the 2D and 3D comb output to be proportionally mixed. If the gain is increased, a smaller percentage of input differences cause mixing, and the probability of application of the 2D comb is increased.

The boundary of a flashing box is unlikely to be affected by this control. One side of the box has no frame differences, whereas the other side has a large difference, resulting in a clear choice of 2D and 3D filters. (A smooth continuous spatial transition between 2D and 3D filters is provided by other means).

This control can be utilized if there is a smooth and slow temporal transition in succeeding frames. Some examples are a slowly moving T pulse (that is, a band-limited pulse), changing colors of the sky, scenes with mist or smoke moving on stationary objects, scene change with slow fade out, etc., where the differences in the pixels between adjacent frames are small. If artifacts appear, gain can be increased to reduce the area where 2D and 3D comb are mixed, since the 3D comb is likely to cause artifacts. On the other hand in pictures with intermittent motion, if it is desired to increase the transition time from 2D to 3D (or 3D to 2D) then the slope can be reduced. Using a gain value of zero for both chroma and luma will force the 3D comb to be applied on the entire picture.

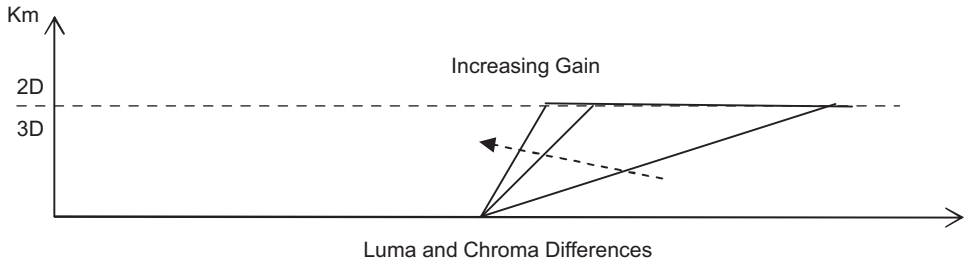

Figure 3. 3DYC Transfer Function – Gain Control

5.2.1 Luma Gain

The Luma Gain register is an 8-bit register that controls the gain (or attenuation) for inter-frame luma difference. Least significant 3 bits specify a fractional gain. Gain can vary from 0 to 31.875 in steps of 0.125. The minimum value of 0 favors 3D comb output, and the maximum value of 31.875 favors 2D comb output.

5.2.2 Chroma Gain

The Chroma Gain register is an 8-bit register that controls the gain (or attenuation) for interframe chroma difference. Least significant 3 bits specify a fractional gain. Gain can vary from 0 to 31.875 in steps of 0.125. The minimum value of 0 favors 3D comb output, and the maximum value of 31.875 favors 2D comb output.

5.3 3DYC Signal Quality Coring and Gain (89h to 8Bh)

When the input signal quality is not good (for example, weak broadcast signals or poor VCR signals), 3D comb filtering is automatically turned off. These controls provide a means to control this automatic feature.

If chroma and/or luma artifacts appear on a signal and the overall picture quality is degraded due to application of 3DYC separation, the signal quality coring threshold can be decreased to favor the application of 2DYC separation. Burst phase difference between frames is used to determine if the quality of the incoming signal is acceptable for the application of 3D comb filter.

The control quantity is generated using the scheme shown in Figure 1, providing the user with a threshold and gain. A larger threshold and smaller gain favor the application of 3D comb filter.

6 Troubleshooting

The following is troubleshooting procedure to help resolve extraordinary artifacts visible when using the TVP5160 3DYC. The procedure helps identify whether the artifact is related to 2DYC or 3DYC. If related to 3DYC, it provides recommendations to resolve the artifacts depending whether they are found in areas of motion or static.

It is important to make sure that the CVBS input to the TVP5160 is of good quality and that the signal is not aliasing. This can be achieved by using a simple anti-aliasing filter on the CVBS input. Aliasing artifacts can be seen as motion, hindering the effectiveness of the 3DYC. Also it is important to ensure proper video cables are used for the input. Improper cables such as audio RCA cables can cause shadowing, ghosting, and ringing in the video. If a video splitter must be used, it is best to use a studio-quality active video switch.

1. Turn off the 3DYC to see if the particular artifact goes away.
2. If it does not, then the artifact is due to 2D comb filter.
3. If it does, then the artifact is due to 3D comb; go to step 4.
4. Check if the artifact is in static areas or motion areas of the video.
5. If the artifact is in the motion areas, the 3DYC is recognizing no motion when there is motion and both chroma and luma comparison yield no change. Determine which change is larger, chroma or luma.
   (a) See if the color change on that pixel artifact is visible.
   (b) Turn off color by using color saturation. See if luma change on the pixel is visible.
   (c) Decide if luma or chroma has the larger change. For example, say it is luma.
   (d) Because we want to recognize motion, reduce the threshold of ONLY the quantity that has the larger change. In our example, that is luma. Reduce only the minimum amount that is required. the trade off is that a static picture may have more pixels in 2D.
6. If the artifact is in a static area, the 3DYC is recognizing motion when there is no motion, and either the chroma or the luma comparison is indicating change. Determine which change is larger, chroma or luma.
   (a) Increase luma coring slowly. If there is not much change, return to original setting. If artifact is reduced, use the minimum level that is better than competition. Eliminating the artifact typically causes other artifacts.
   (b) Increase chroma coring slowly. If there is not much change, return to original setting. If artifact is reduced, use the minimum level that is better than competition. Eliminating the artifact typically causes other artifacts.

   NOTE: Increase ONLY the quantity that has most effect with least change. If both are increased, expect to see dot crawl in motion areas.
7. For slow moving or intermittent moving images, use the above procedure for threshold first. If it is not satisfactory, reduce the gain to make the transition from 2D to 3D (and 3D to 2D) slower. Expect to see increased false color and dot crawl with reduced gain.
8. If the signal is from a broadcast or cable channel and is of poor quality, adjust signal quality threshold as explained in the TVP5160 data manual (SLES135).

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		**Applications**	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com	Wireless	www.ti.com/wireless-apps
RF/IF and ZigBee® Solutions	www.ti.com/lprf		
	TI E2E Community Home Page		e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265