Application Report
SLEA058–July 2006

Using the Scaler in the TVP5154

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ABSTRACT

The TVP5154 video decoder product includes the additional functionality of an integrated polymorphic down-scaler for both vertical and horizontal scaling. The video images can be downscaled in both horizontal and vertical directions to an arbitrary size. This Application Note outlines how to correctly use this scaler feature for standard NTSC and PAL video. Also included are the register settings for several scaling ratio examples and the required I^2C writes for one example. A Windows executable program is available to calculate the register settings for additional scaling ratios.

1 Functional Description

The TVP5154 contains independent horizontal and vertical downscalers for all four decoder cores.

The horizontal scaling ratio is defined by five integer and ten fractional bits, and is variable on a 2-pixel resolution. The horizontal filter is a 7-tap horizontal filter with 32 phases. A *pixel picking* algorithm selects a defined number of pixels from the input line, ensuring that the picked pixels are distributed equally in the line.

The vertical scaling ratio is defined by nine integer bits, providing scaling from 1 to 1/256, variable on a 2-pixel resolution. The vertical scaler includes a variable running average filter whose length depends on the scaling ratio. The cutoff point varies, thereby ensuring no aliasing in the resulting image. The horizontal and vertical scaling are independent of each other.

The algorithm is optimized for space and power considerations. A one-line buffer (FIFO) is used for line transfers, and no frame memory is used for the scaler. Because the TVP5154 does not have a frame buffer, it cannot squeeze the data into contiguous rows. The output, one line at a time, is spread across the screen vertically. The backend must use the active video pulse (AVID) to decide which row is active and which is not. AVID can be easily observed on the oscilloscope; it changes width, based on the number of output pixels desired. It is active only for *active* rows after scaling has been completed.

Each scaler is programmed using a series of I^2C writes to the TVP5154 indirect registers; each indirect write comprises four direct writes. The registers and programming steps are outlined below for use with both the EVM board provided by TI (with the bundled WinVCC software) and with the customer system.

This process is illustrated in the example I^2C writes below. There are comments that explain each step that is to be done.

A Windows executable program, *TVP5154 Scaler Settings.exe*, is available to calculate the register settings for additional scaling ratios. The input and output resolutions can be input from the user, and the resulting scaler register settings are calculated. The results can be output to a txt file, *TVP5154 Scaler Settings.txt*, which can be found in the same directory as the program. The text file will contain all necessary I^2C writes to enable and program the scaler for the desired scaling ratio.

2 Programming the Scaler

The user should follow these steps to correctly program the scaler:

1. Initialize the TVP5154, power up the scaler, and choose the correct output mode. The scaler is powered off by default, and the default output mode is for unscaled data.
2. Program the scaler register values for the desired horizontal and vertical scaling.

The first step is only at power up. Subsequent to this, only programming the register values for the horizontal and vertical scaling is required. The user can program the values for the horizontal and vertical scaling independently.

3 Initialization Registers for the TVP5154 and the Scaler

- The TVP5154 can be initialized with as few as two I^2C register writes:
  Write 0x00 to I^2C register 0x7F – This restarts the TVP5154 microprocessor
  Write 0x0D to I^2C register 0x03 – This enables YCbCr and sync/control outputs
- To power up the TVP5154 scaler and to choose the scaled data output mode, perform the following I^2C writes:
  Write 0x1B to I^2C register 0x17 – This powers up the scaler and enables SAV/EAV codes
  Write 0x01 to I^2C register 0x1F – This selects the scaled data output mode, with Clock 1
- Additional registers such as 0x17, 0x25–0x26, and 0x29–0x2A are used to control other scaler-related settings, such as the scaled AVID signal and scaler SAV/EAV codes. Refer to the TVP5154 data sheet, TI literature number SLES163, for more details about these and other scaler-related registers.

4 Scaling Registers for the TVP5154

Downscaling is conducted by programming the horizontal and vertical scaling registers. For horizontal scaling, registers 0x3AB, 0x3AC, and 0x3AD must be programmed. For vertical scaling, registers 0x3A8, 0x3A9, and 0x3AC must be programmed. These indirect registers can be controlled through the I^2C bus; each indirect write comprises four direct I^2C writes to registers 0x21 to 0x24. A password must first be unlocked in the TVP5154 to enable writes to these indirect registers (see example below.) Refer to the TVP5154 data sheet and the application note, *TVP5154 Indirect Registers*, TI literature number SLEA057, for more details on how to access these indirect registers.

The two primary scaling values that must be calculated are the horizontal and vertical scaling coefficients.

HORZ_COEF = input pixels/output pixels

VERT_COEF = (output lines/input lines) $\times$ 256

Examples of these coefficients for several scaling ratios are listed in Table 1. These values are used to calculate the scaling register settings.

Table 1. Examples of HORZ_COEF and VERT_COEF Values

SCALING RATIO	FORMAT	OUTPUT RESOLUTION	HORZ_COEF (5.10)	VERT_COEF (9)
1	NTSC PAL	720×480 720×576	0x400	0x100
1/2	NTSC PAL	360×240 360×288	0x800	0x80
1/4	NTSC PAL	180×120 180×144	0x1000	0x40

4.1 Detailed Description of Scaling Registers

The values programmed for registers 3A8h and 3A9h are different for NTSC (also NTSC4.43 and PAL-M) and for PAL (also PAL-Nc and SECAM).

4.1.1 Vertical Scaling Field 1 Control

Address 3A8h
Default 0h

7	6	5	4	3	2	1	0
V_Field1[7:0]							
15	14	13	12	11	10	9	8
Reserved							V_Field1[8]

Vertical scaling initial value in field 1 [8:0]: Initial value of vertical accumulator for field 1

For NTSC: V_Field1 = (1.5 × V_Field2) – 128

If V_Field1 is negative, then add V_Field2 to V_Field1 and add V_Field2 to V_Field2 until V_Field1 is positive.

For PAL: V_Field1 = (Vdesired/Vactive) × 256

4.1.2 Vertical Scaling Field 2 Control

Address 3A9h
Default 0h

7	6	5	4	3	2	1	0
V_Field2[7:0]							
15	14	13	12	11	10	9	8
Reserved							V_Field2[8]

Vertical scaling initial value in field 2 [8:0]: Initial value of vertical accumulator for field 2

For NTSC: V_Field2 = (Vdesired/Vactive) × 256

For PAL: V_Field2 = (1.5 × V_Field1) – 128

If V_Field2 is negative, then add V_Field1 to V_Field2 and add V_Field1 to V_Field1 until V_Field2 is positive.

4.1.3 Scaler Output Active Pixels

Address 3ABh
Default 2D0h

7	6	5	4	3	2	1	0
SCAL_PIXEL[7:0]							
15	14	13	12	11	10	9	8
Reserved						SCAL_PIXEL[9:8]	

SCAL_PIXEL [9:0]: Scaler active pixel outputs per line (Hdesired).

4.1.4 Vertical Scaling Control

Address 3ACh
Default 2100h

7	6	5	4	3	2	1	0
VERT_COEF[7:0]							
15	14	13	12	11	10	9	8
Reserved		1	Enable	Reserved			VERT_COEF[8]

Enabled: Enable vertical and horizontal scaler

0 = Disable scaler (default)

1 = Enable scaler

VERT_COEF [8:0]: Vertical scaling coefficient

VERT_COEF = (Vdesired/Vactive) × 256

4.1.5 Horizontal Scaling Control

Address 3ADh

Default 400h

7	6	5	4	3	2	1	0
HORZ_COEF[7:0]							
15	14	13	12	11	10	9	8
Reserved	HORZ_COEF[14:8]						

HORZ_COEF[14:0]: Horizontal scaling coefficient, MSB 5 bits are integer values, and LSB 10 bits are fraction numbers.

HORZ_COEF = Hactive / Hdesired

5 Examples

Examples of the register settings are given below for various commonly used input formats and scaling ratios.

Table 2. Most Commonly Used Resolutions

RESOLUTIONS		
FORMAT	**PIXELS**	**LINES**
NTSC	720	480
PAL	720	576
SIF	352	240
QSIF	176	120
CIF	352	288
QCIF	176	144
VGA	640	480
QVGA	320	240

Table 3. Register Values for Most Commonly Used Video Formats and Scaling Ratios

SCALING REGISTERS						
IN	**OUT**	**3A8**	**3A9**	**3AB**	**3AC**	**3AD**
NTSC	QSIF	20	80	B0	3040	105D
NTSC	SIF	40	80	160	3080	82E
NTSC	QCIF	40	9A	B0	304D	105D
NTSC	CIF	67	9A	160	309A	82E
NTSC	QVGA	40	80	140	3080	900
NTSC	VGA	100	100	280	3100	480
PAL	QSIF	6A	4	B0	3035	105D
PAL	SIF	6B	21	160	306B	82E
PAL	QCIF	80	20	B0	3040	105D
PAL	CIF	80	40	160	3080	82E
PAL	QVGA	6B	21	140	306B	900
PAL	VGA	D5	C0	280	30D5	480

The following example shows the required I²C writes to enable TVP5154 scaling from NTSC (720×480) input to SIF (352×240) output.

I²C SUBADDRESS	DATA	DESCRIPTION
0x7F	0x00	Restart the TVP5154 microprocessor
0x03	0x0D	Enable YCbCr and sync/control outputs
0x1F	0x01	Enable scaler mode
0x17	0x1B	Disable scaler powerdown; enable SAV/EAV codes
0x21	0x51	Unlock password for indirect register writes
0x22	0x54	
0x23	0xFF	
0x24	0x04	
0x21	0x30	0x3AC(bit 12) = 1 – Enable scaler 0x3AC(8:0) = x80 – Vertical scaling ratio
0x22	0x80	
0x23	0xAC	
0x24	0x06	
0x21	0x00	0x3A8(8:0) = x40 – Init value of Field 1 vertical accumulator
0x22	0x40	
0x23	0xA8	
0x24	0x06	
0x21	0x00	0x3A9(8:0) = x80 – Init value of Field 2 vertical accumulator
0x22	0x80	
0x23	0xA9	
0x24	0x06	
0x21	0x08	0x3AD(14:0) = x082E – Horizontal scaling ratio
0x22	0x2E	
0x23	0xAD	
0x24	0x06	
0x21	0x01	0x3AB(9:0) = x160 – Number of output active pixels per line
0x22	0x60	
0x23	0xAB	
0x24	0x06	

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