

H1A424M167

**Image Signal Processor
for Hyundai CMOS Image Sensor**

Data Sheet

Version 1.0

REVISION HISTORY

Revision	Issue Date	Comments
0.45	April 28, 1999	Draft
0.9	June 15, 1999	Added Suspend Pin(No.16) Added Flicker Free Banding noise filter Added Histogram Equalization function Added STATUS_FLAGS register Modified Gamma Correction function Modified AWB/AE function
0.95	August 10, 1999	Added CIF type CIS(HV7121X) support function Added X-flip function Modified Edge Enhancement filter JFIF color space conversion equation Modified BASE_ENB register Modified STATUS_FLAGS register Modified AWB/AE function
1.0	October 11, 1999	Added Functional Description/Register Description Added Soldering Description Formal Release

TABLE OF CONTENTS

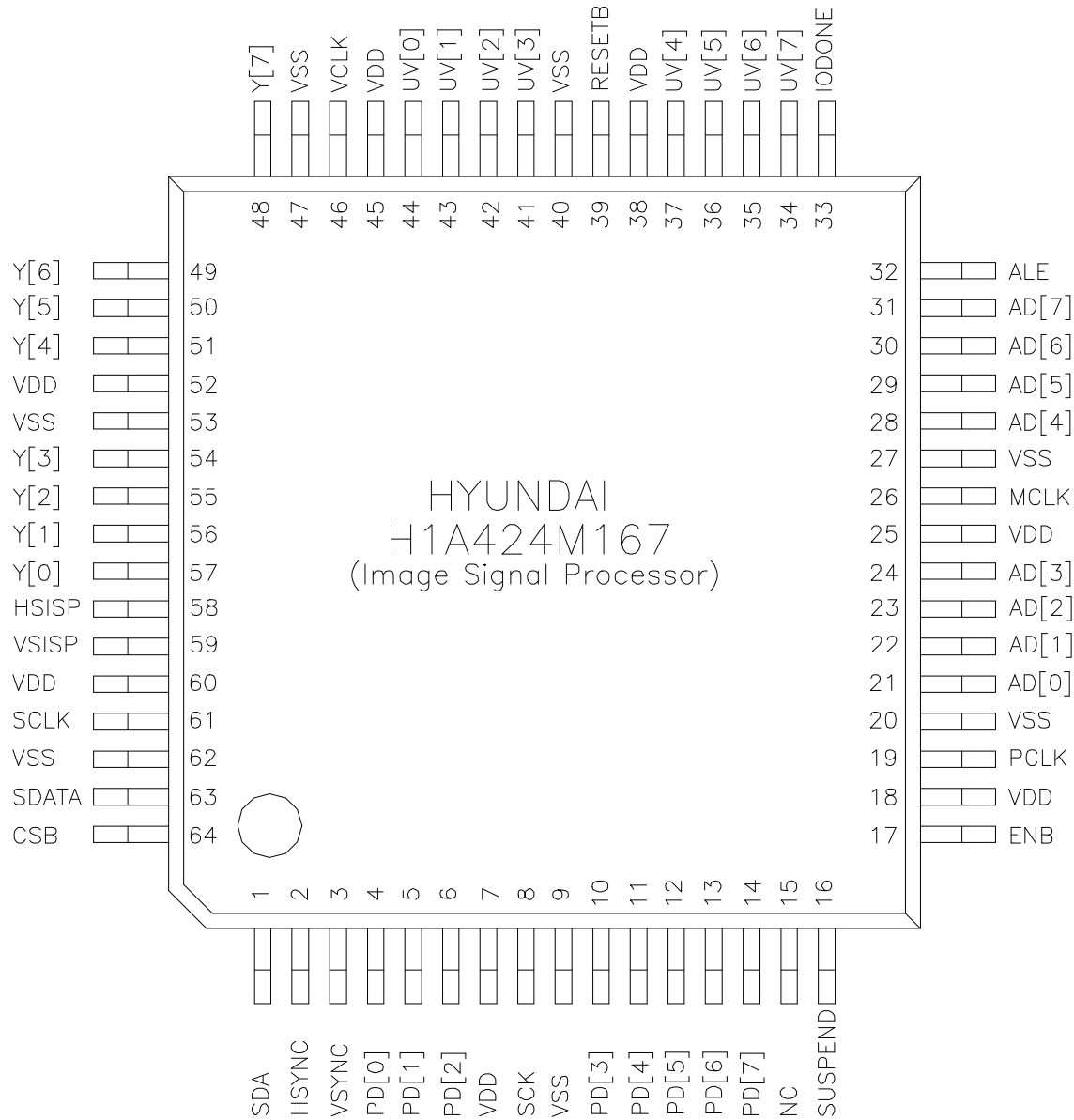
1. FEATURES	5
2. PIN CONFIGURATION.....	6
3. PIN DEFINITION.....	7
4. SYSTEM DIAGRAM.....	10
5. BLOCK DIAGRAM	10
6. VIDEO PROCESSING ENGINE BLOCK DIAGRAM	11
7. FUNCTIONAL DESCRIPTION.....	12
7.1. HOST INTERFACE	12
7.1.1. <i>Serial Interface</i>	12
7.1.2. <i>Host Parallel Interface</i>	14
7.1.3. <i>Serial or Parallel Interface selection</i>	15
7.2. CLOCK(MCLK, PCLK, VCLK) TIMING DIAGRAM	16
7.3. VIDEO OUTPUT INTERFACE.....	16
7.4. RELATIONS BETWEEN INPUT VIDEO TIMING AND OUTPUT VIDEO TIMING	17
7.4.1. <i>VGA</i>	18
7.4.2. <i>CIF</i>	18
7.4.3. <i>SIF</i>	19
7.4.4. <i>QCIF</i>	19
7.4.5. <i>QSIF</i>	20
8. REGISTER DESCRIPTION	21
8.1. REGISTERS MNEMONIC TABLE.....	21
8.2. BASE REGISTER MAP.....	24
8.2.1. <i>Normal Register[80h~83h]</i>	24
8.2.2. <i>Color Matrix Coefficients Value[8Ah ~ 95h]</i>	26
8.3. AUTO REGISTER MAP	29
8.3.1. <i>Function Enable Register[A0h]</i>	29
8.3.2. <i>AWB/AE Windows Configuration Registers[A1h~A6h]</i>	30
8.3.3. <i>Normal Register[A7h~B8h]</i>	31
8.4. OUT REGISTER MAP.....	37
8.4.1. <i>Normal Register[C0h~C2h]</i>	37

8.4.2. Histogram Equalization Control Register[C3h~C4h]	38
8.4.3. Gamma Control Register[E0h~F1h].....	39
9. ELECTRICAL CHARACTERISTICS	42
9.1. ABSOLUTE MAXIMUM RATINGS	42
9.2. DC CHARACTERISTICS	42
9.3. AC CHARACTERISTICS	43
9.3.1. Microcontroller Bus Interface timing (Write cycle).....	43
9.3.2. Microcontroller Bus Interface timing (Read cycle).....	43
9.3.3. Serial Interface Control Timing	44
9.3.4. RESETB Timing.....	45
9.3.5. Video Output Timing.....	45
10. PACKAGE SPEC.....	46
11. SOLDERING.....	47
11.1. SOLDER REFLOW EQUIPMENT	47
11.2. REFLOW PROFILES.....	47
11.3. FLUX APPLICATION.....	47
11.4. CLEANING	47
11.5. DRYING	47

1. Features

- Dedicated sensor control and signal processing chip for Hyundai CMOS Image Sensor
- CMOS 3.3V Device (0.5um CMOS TLM Process used)
- Serial-Bus interface or alternative 8-bit MCU parallel interface for register programming
- Serial-Bus interface for HYUNDAI CMOS Image Sensor Chip Control
- 8 bit Bayer format image input
- 3 x 3 Interpolation
- Color Correction matrix
- Gamma Correction
- Automatic Exposure Control
- Automatic White Balance Control
- Programmable AE/AWB windows
- Automatic Reset Level Control
- Edge Enhancement Support
- 2x2, 4x4 Sub-Sampling(CIF, QCIF)
- RGB to YCrCb Color Space Convert
- Histogram Equalization Logic
- 16bit YUV 4:2:2, YUV 4:2:0, 8bit YUV 4:2:2, YUV 4:2:0 video output format
- Flicker Free Banding noise filter
- X Flip Function for mirrored image
- Horizontal and Vertical Sync Information on Separate Pin
- 64 Pin LQFP Package(Standard JEDEC Package)

2. Pin Configuration



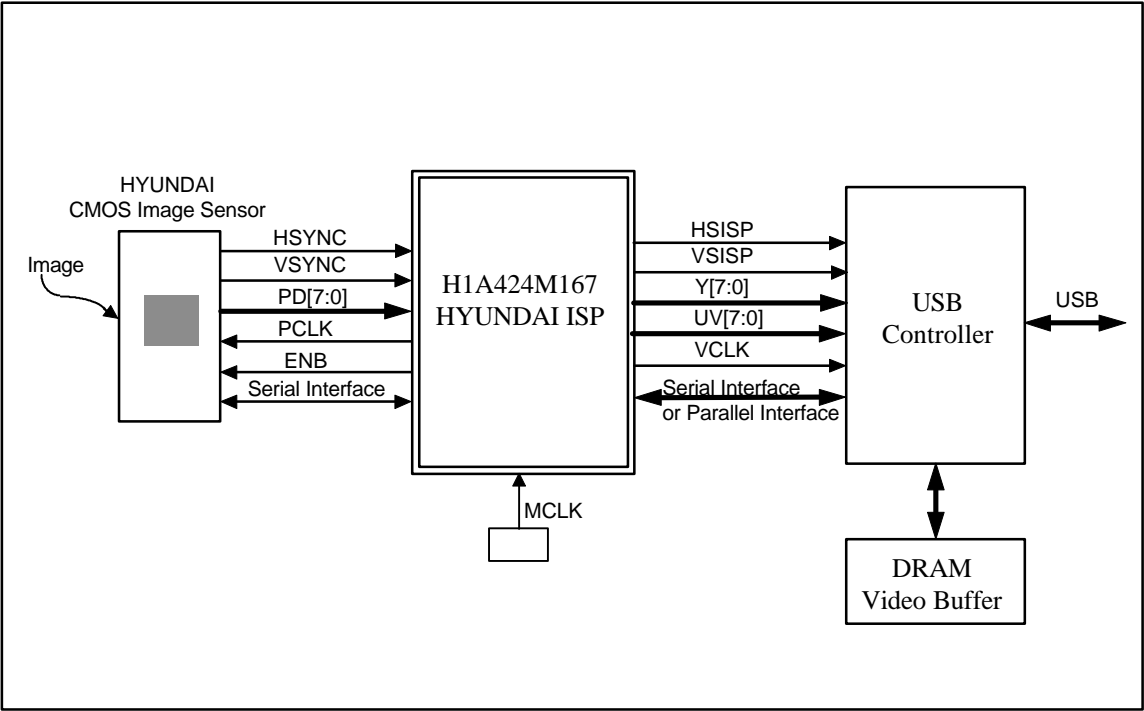
3. Pin Definition

Pin Number	Pin Name	Type	Description
1	SDA	B	Serial Data for CMOS Image Sensor Control
2	HSYNC	I	Horizontal SYNC Signal from CMOS Image Sensor
3	VSYNC	I	Vertical SYNC Signal from CMOS Image Sensor
4	PD[0]	I	Raw Pixel Data from Image Sensor Chip
5	PD[1]	I	Raw Pixel Data from Image Sensor Chip
6	PD[2]	I	Raw Pixel Data from Image Sensor Chip
7	VDD	P	Power Pin, 3.3V
8	SCK	O	Serial Clock for CMOS Image Sensor Control
9	VSS	G	Ground Pin
10	PD[3]	I	Raw Pixel Data from Image Sensor Chip
11	PD[4]	I	Raw Pixel Data from Image Sensor Chip
12	PD[5]	I	Raw Pixel Data from Image Sensor Chip
13	PD[6]	I	Raw Pixel Data from Image Sensor Chip
14	PD[7]	I	Raw Pixel Data from Image Sensor Chip
15	NC	-	No Connection
16	SUSPEND	I	Suspend Mode Support Pin, Active high
17	ENB	O	CMOS Image Sensor Enable
18	VDD	P	Power Pin, 3.3V
19	PCLK	O	Pixel Clock for CMOS Sensor (MCLK / 3)
20	VSS	G	Ground Pin
21	AD[0]	B	Address/Data Bus for MCU interface
22	AD[1]	B	Address/Data Bus for MCU interface
23	AD[2]	B	Address/Data Bus for MCU interface
24	AD[3]	B	Address/Data Bus for MCU interface
25	VDD	P	Power Pin, 3.3V
26	MCLK	I	Master Clock Input
27	VSS	G	Ground Pin
28	AD[4]	B	Address/Data Bus for MCU interface
29	AD[5]	B	Address/Data Bus for MCU interface
30	AD[6]	B	Address/Data Bus for MCU interface

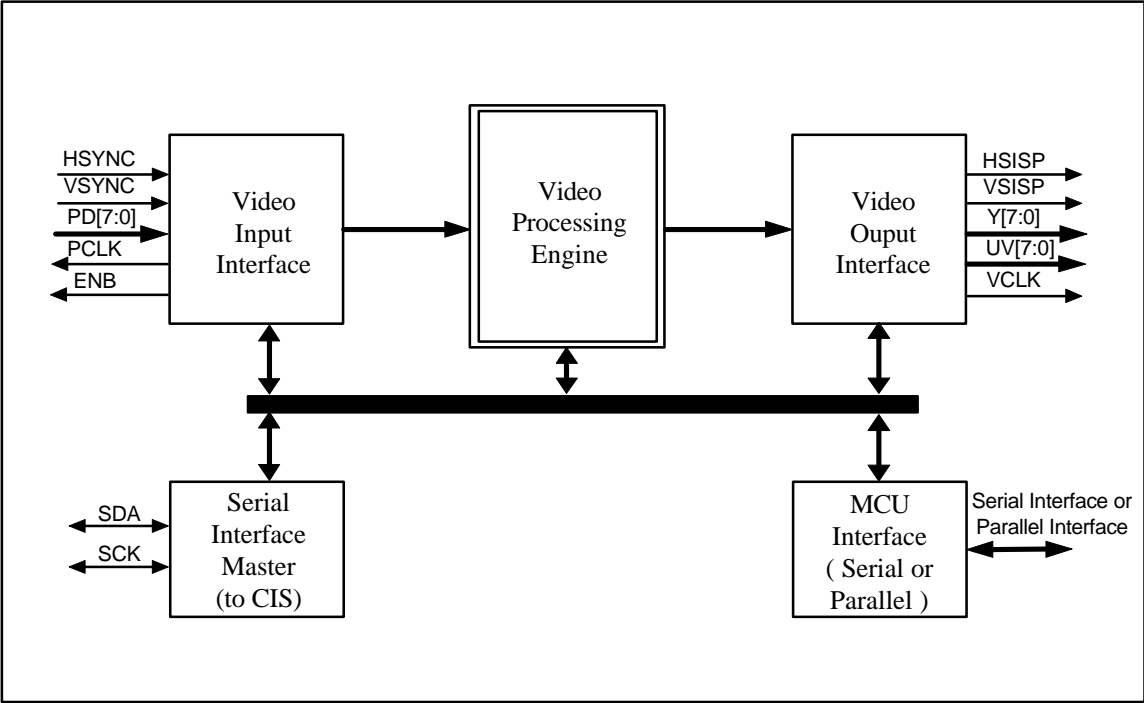
31	AD[7]	B	Address/Data Bus for MCU interface
32	ALE	I	Address Latch Enable
33	IODONE	O	CIS/ISP Read/Write Done
34	UV[7]	O	Video Data Output for CrCb
35	UV[6]	O	Video Data Output for CrCb
36	UV[5]	O	Video Data Output for CrCb
37	UV[4]	O	Video Data Output for CrCb
38	VDD	P	Power Pin, 3.3V
39	RESETB	I	ISP Reset, Active Low
40	VSS	G	Ground Pin
41	UV[3]	O	Video Data Output for CrCb
42	UV[2]	O	Video Data Output for CrCb
43	UV[1]	O	Video Data Output for CrCb
44	UV[0]	O	Video Data Output for CrCb
45	VDD	P	Power Pin, 3.3V
46	VCLK	O	Pixel Clock for Video Output
47	VSS	G	Ground Pin
48	Y[7]	O	Video Data Output for Y
49	Y[6]	O	Video Data Output for Y
50	Y[5]	O	Video Data Output for Y
51	Y[4]	O	Video Data Output for Y
52	VDD	P	Power Pin, 3.3V
53	VSS	G	Ground Pin
54	Y[3]	O	Video Data Output for Y
55	Y[2]	O	Video Data Output for Y
56	Y[1]	O	Video Data Output for Y
57	Y[0]	O	Video Data Output for Y
58	HSISP	O	Horizontal SYNC Signal for Video Data Output
59	VSISP	O	Vertical SYNC Signal for Video Data Output
60	VDD	P	Power Pin, 3.3V
61	SCLK/IOR	I	Serial Bus Clock for programming ISP, Can be used as IOR when MCU interface configuration
62	VSS	G	Ground Pin
63	SDATA/IOW	B	Serial Bus Data for programming ISP, Can be used as IOW when MCU interface configuration

64	CSB/MODE	I	ISP chip select when MCU interface configuration During reset time, this pin operates as interface mode
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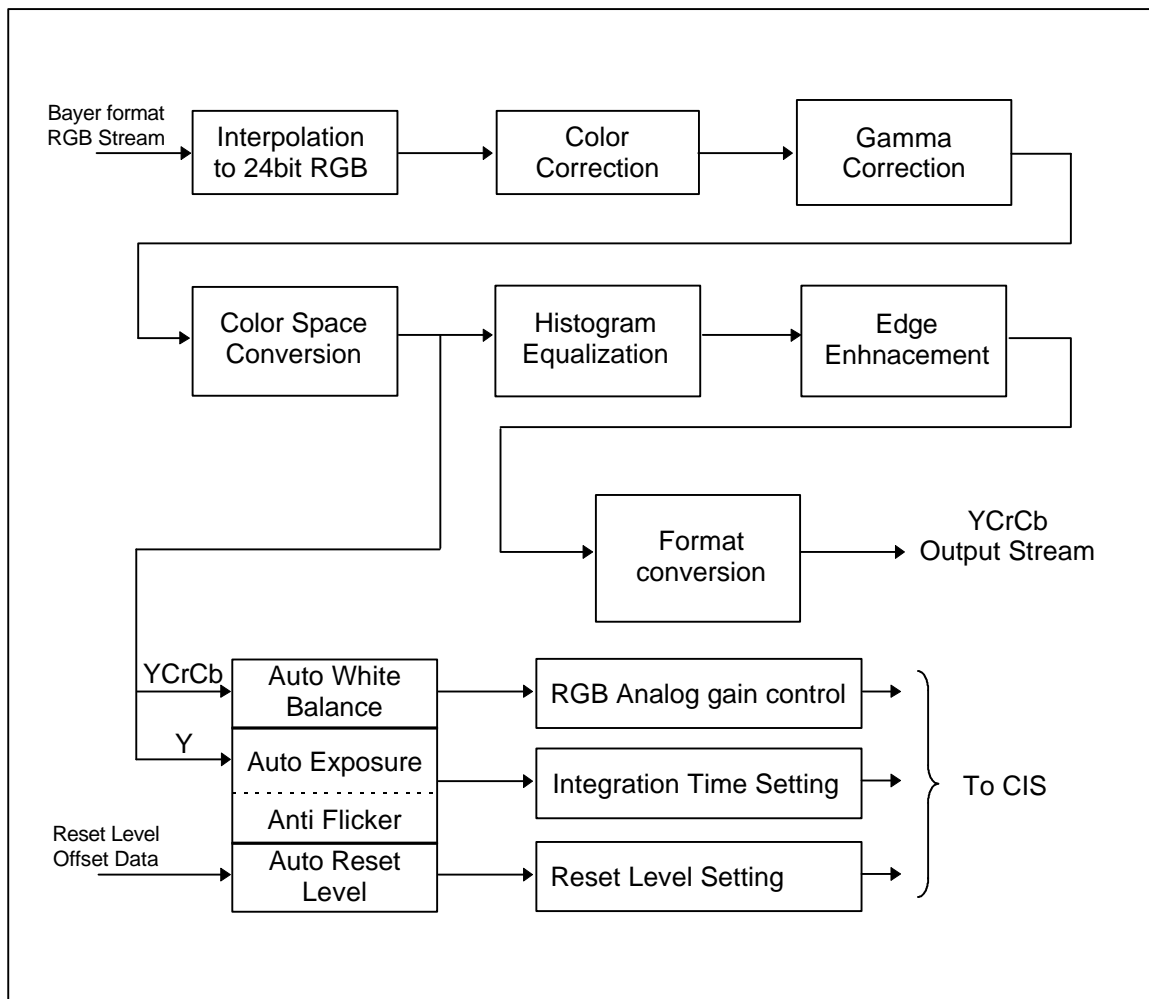
4. System Diagram



5. Block Diagram



6. Video Processing Engine Block Diagram



7. Functional Description

7.1. Host Interface

Hyundai ISP chip supports two kinds of host interface, serial and 8bit parallel, to program ISP registers or to read ISP registers. And the host interface is also used to write or to read CMOS Image Sensor(CIS) registers through ISP.

7.1.1. Serial Interface

The serial interface of Image Signal Processor[ISP] is implemented by the following pins.

SCLK: Serial Clock SDATA: Serial Data

7.1.1.1. WRITE OPERATION

Write transaction between the ISP and a host is the similar as the well-known I2C serial interface except that only one byte transfer at each transaction is allowed. The transaction consists of START CONDITION, DEVICE ADDR + R/W[0], SUB ADDR, WRITE DATA, and STOP CONDITION states. The single write access sequence is as follows.

S	DEVICE ADDR	A1	SUB ADDR	A2	WRITE DATA	A3	P
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[S]	Operation start condition
[DEVICE ADDR]	ISP 40h (010_0000 + 0), CIS 22h (001_0001 + 0) ⇒ device address + R/W bit
[A1]	Acknowledge from ISP
[SUB ADDR]	ISP Sub address space 80h ~ FFh CIS Sub address space 00h ~ 7Fh
[A2]	Acknowledge from ISP
[WRITE DATA]	Register Value from host
[A3]	Acknowledge from ISP
[P]	Operation stop condition

7.1.1.2. READ OPERATION

Read transaction between the ISP and a host proceeds as the following sequence.

START CONDITION ⇒ DEVICE ADDR + R/W[0] ⇒ SUB ADDR ⇒ START CONDITION ⇒ DEVICE ADDR + R/W[1] ⇒ READ DATA ⇒ STOP CONDITION

The ISP register access throughput is one byte at each read transaction. But the

CMOS Image Sensor register access through the ISP chip needs two sequential read operations to compensate the read access delay from CMOS Image Sensor to ISP. The second read data for the CMOS image sensor register should be recognized as the right value of the accessed register. But when the ISP auto functions are enabled, there will be a variable delay for the right data transfer from the CMOS image sensor to the ISP at the first read access, so the second read access may not get acknowledge from the ISP until the first read access is completely processed in the ISP. To take care of the said situation, a system host should repeat the second read access until it get acknowledge from the ISP or there should be sufficient delay between two accesses. To summarize, the ISP general register read access is always completed by only one read transaction, and the CMOS image sensor register access needs two fully acknowledged read transactions and the last read data is the right value for the accessed register.

The single read access sequence is as follows.

S1	DADDR 1	A1	SADDR	A2	S2	DADDR 2	A3	READ DATA	A4	P
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[S1]	Start condition
[DADDR 1]	Device Address ISP 40h (010_0000 + 0), CIS 22h (001_0001 + 0) ⇒ device address + R/W bit
[A1]	Acknowledge from ISP
[SADDR]	ISP Sub address space 80h ~ FFh CIS Sub address space 00h ~ 7Fh
[A2]	Acknowledge from ISP
[S2]	Start condition
[DADDR 2]	Device Address ISP 41h (010_0000 + 1), CIS 23h (001_0001 + 1) ⇒ device address + R/W bit
[A3]	Acknowledge from ISP
[READ DATA]	Register Value from ISP
[A4]	Acknowledge from HOST
[P]	Stop condition

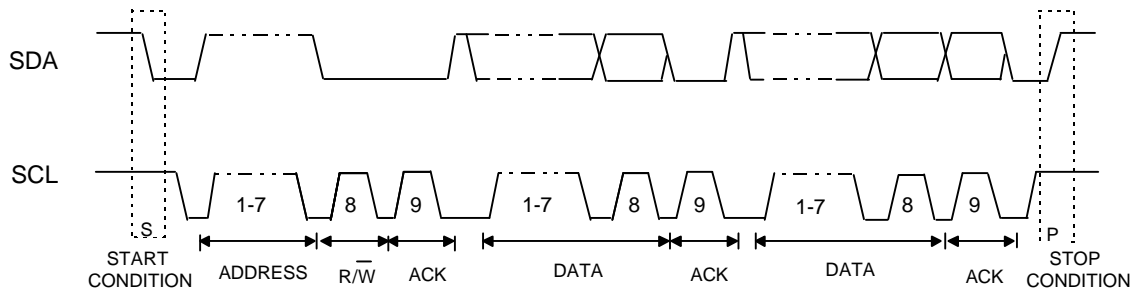
* Note (Importance !)

ISP General Register Read : 1 Read Operation needed.

CIS Register Read : 2 Read Operation needed, valid data at second read operation.

ISP recognize CIS read command at first read.

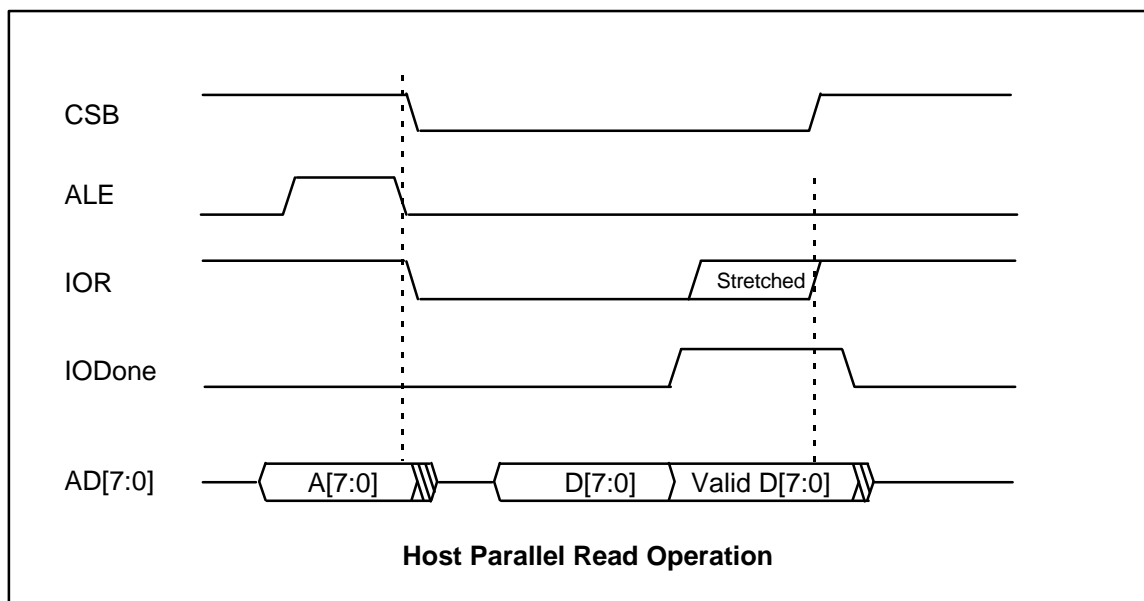
7.1.1.3. Data Transfer Timing on the serial Interface



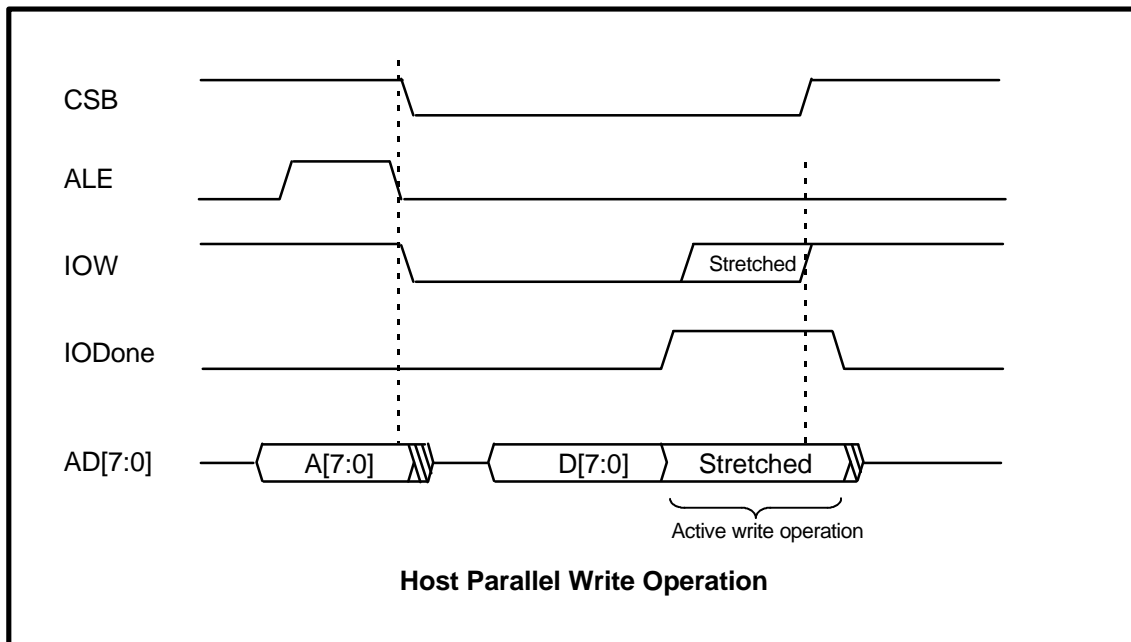
7.1.2. Host Parallel Interface

H1A424M167 ISP supports an external 8-bit microcontroller interface to access H1A424M167 internal registers.

Basically, the data transfer operations(8bits) are multiplexed on the address bus.



A Parallel read operation always needs only 1 read cycle different from the serial read operation. But the host must watch 'IODone' signal for a proper read operation. IODone signal indicates the completion of read/write operation. So the host must hold the IOR, CSB signals until IODone signal is active, to read the valid data on AD[7:0] lines. At the final stage, the host ends the bus cycle(CSB, IOR) then IODone signal become inactive.



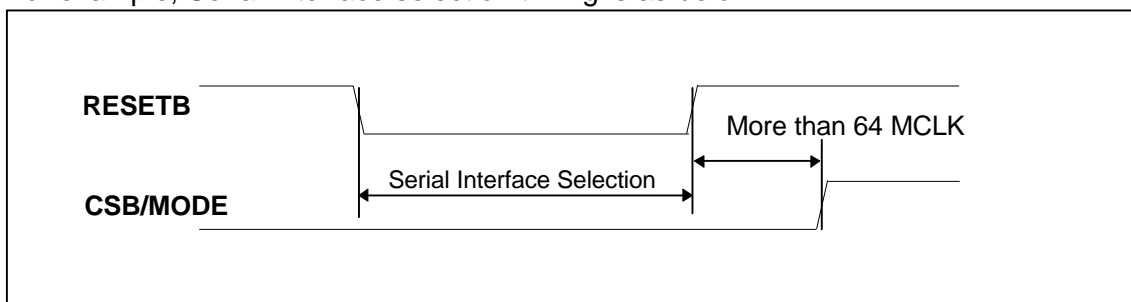
Similar to parallel read operation, parallel write operation needs only 1 operation cycle. The host must watch 'IODone' signal for a proper write operation. IODone signal indicates the completion of read/write operation. So the host must hold the IOW, CSB, Write Data[7:0] signals until IODone signal become active. When IODone signal become active, ISP accept the write data internally. At the final stage, the host ends the bus cycle(CSB, IOW, Write Data[7:0]) and IODone signal become inactive.

ISP holds IODone active until read/write operation is completed. CIS register read/write operation needs more time than ISP register read/write operation. So IODone active signal for CIS register read/write operation is much longer than that of ISP register read/write operation.

7.1.3. Serial or Parallel Interface selection

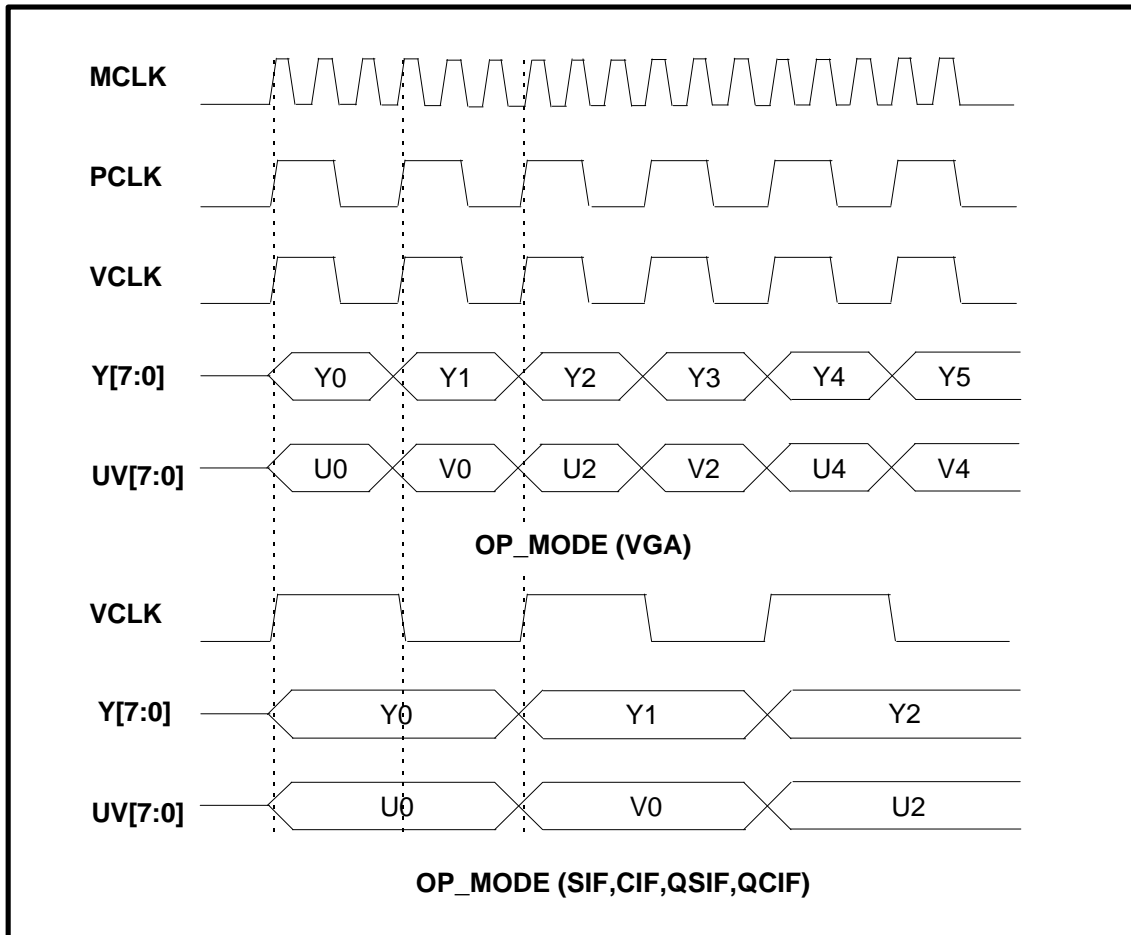
The selection between serial interface and parallel interface is made at hardware reset time. If CSB/MODE pin, pin number 64, is pulled down during reset, Serial Interface is configured, and otherwise parallel interface is selected.

For example, Serial Interface selection timing is as below.



7.2. Clock(MCLK, PCLK, VCLK) Timing Diagram

This chart shows the timing diagram in the YCbCr 4:2:2, 16bit video mode.



* Note : HV7131B(VGA) CMOS Sensor is used for this timing diagram.

7.3. Video Output Interface

The H1A424M167 outputs video data in YUV 4:2:2 format through the 16-bit (Y[7:0] and UV[7:0]) data bus. Video data is changed at the rising edge of the VCLK signal. UV order can be selected by programming OUT_FORM register. VCLK frequency is same to PCLK frequency in VGA mode when the 16-bit video mode is enabled. VCLK frequency is a half of PCLK frequency in SIF,CIF,QSIF,QCIF modes when the 16-bit video mode is enabled. (See OP_MODE register description.)

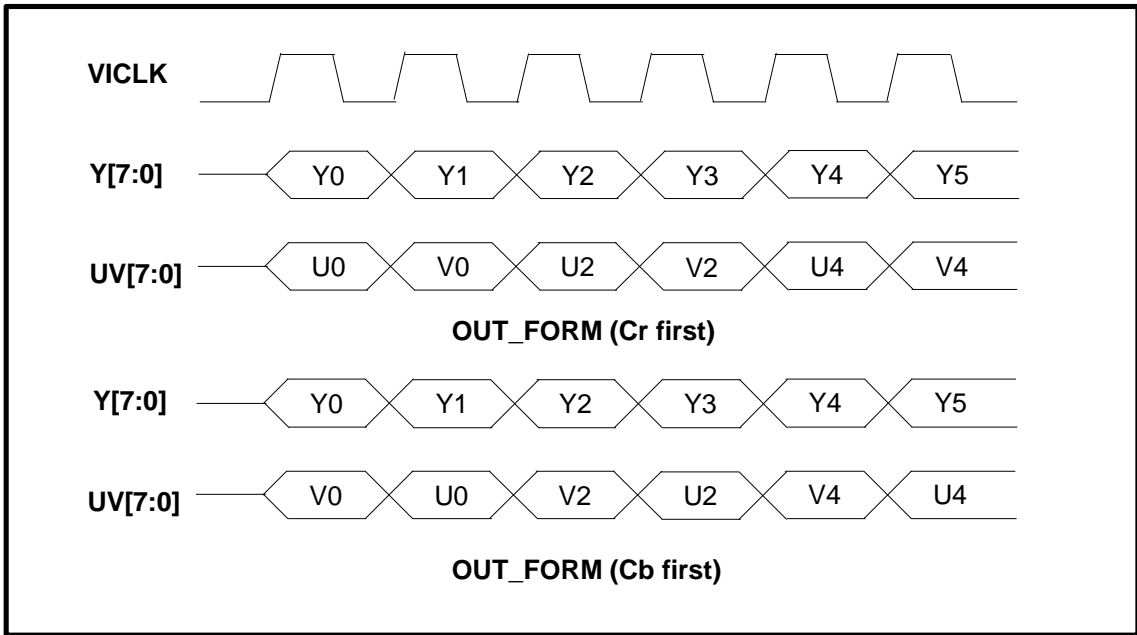
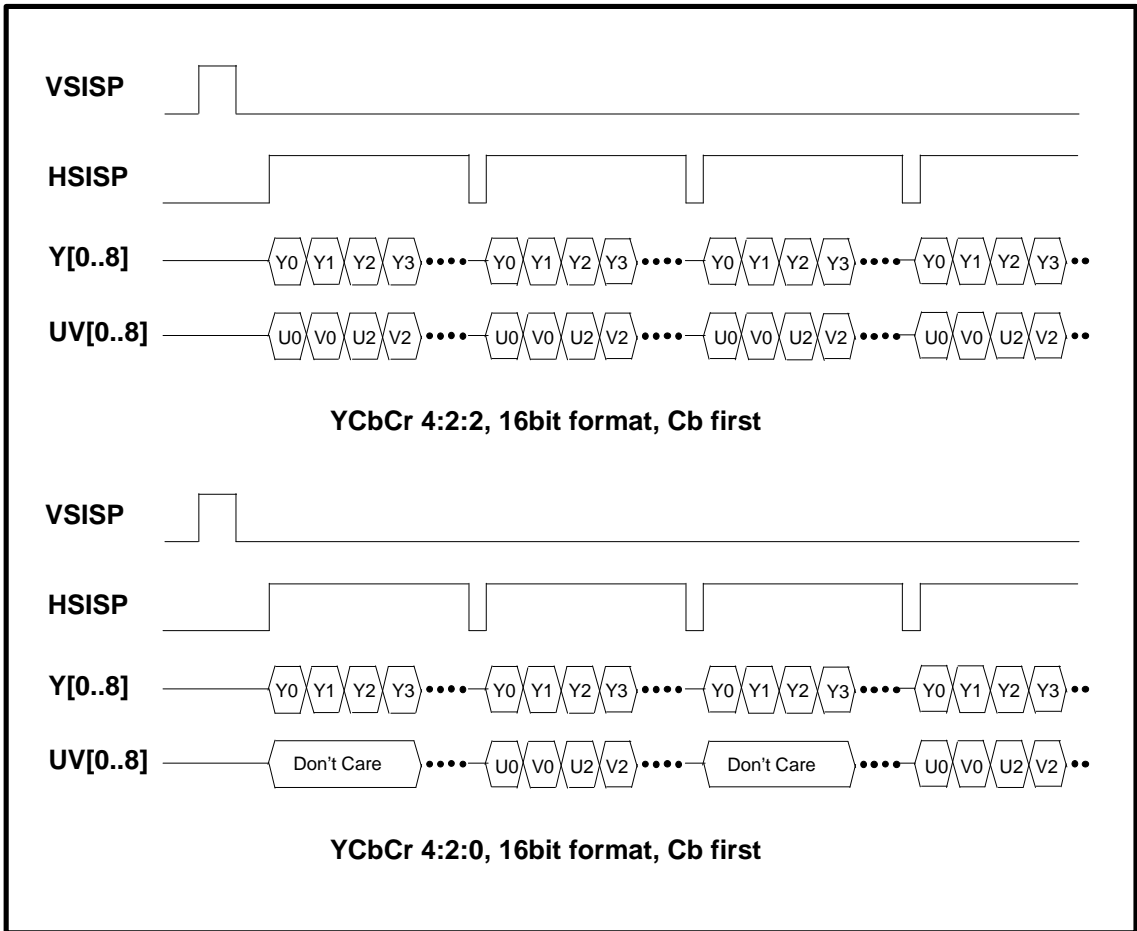
Some video codec needs several HSYNC pulses within active VSYNC. So, The H1A424M167 can modify input VSYNC width by programming HSYNC_COUNT register for VSISP pulse to contain several HSYNC pulses.

All YUV 16bit ports are active for every HSISP lines in YUV 4:2:2, 16bit video mode.

All YUV 16bit ports are active for even HSISP lines, and only Y 8bit ports are active for

odd HSYNC lines in YUV 4:2:0, 16bit video mode.

The following chart shows the video output data format in the 4:2:2, 4:2:0, 16bit video mode.

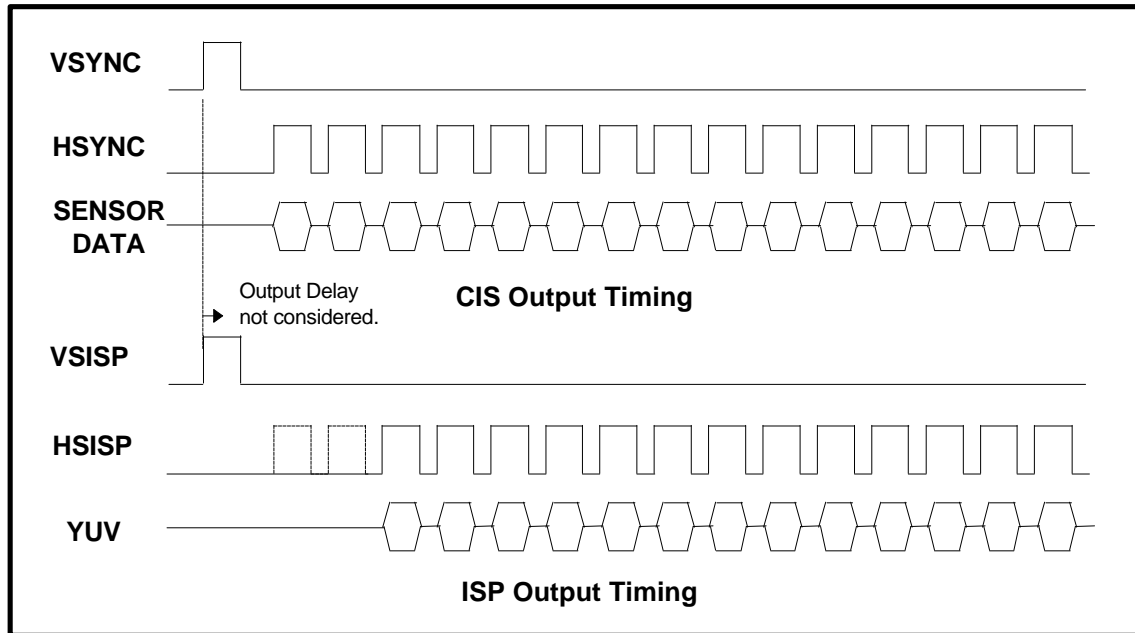


7.4. Relations between input video timing and output video timing

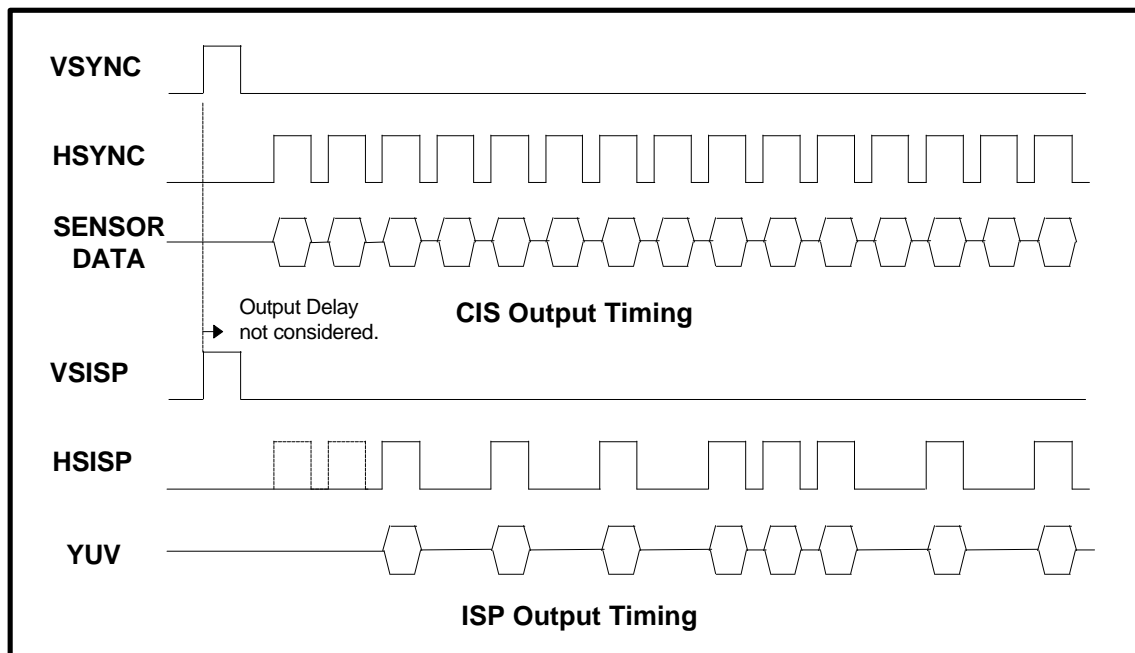
The H1A424M167 have five modes of video output timing - VGA(640X480), CIF(352X288), SIF(320X240), QCIF(176X144), QSIF(160X120) - , when the CMOS Image sensor operates in mode of VGA(640X480). The first pixel color of a frame should be "RED" in order to get correct color interpolated image.

The following timing diagrams show relations on each mode.

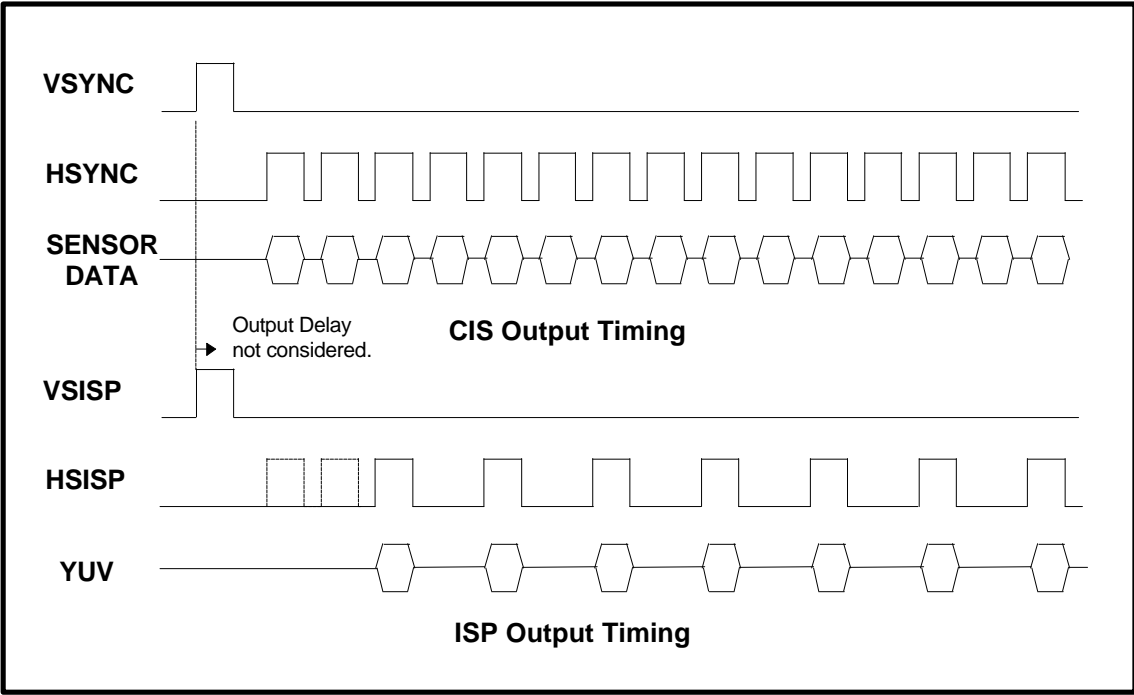
7.4.1. VGA



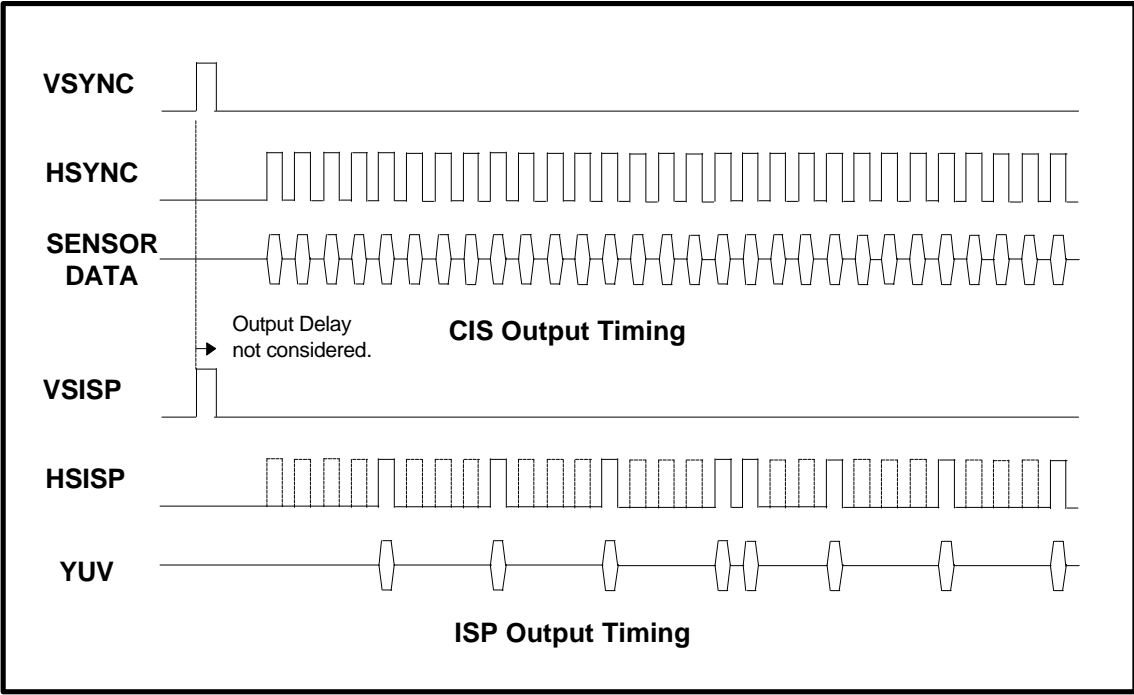
7.4.2. CIF



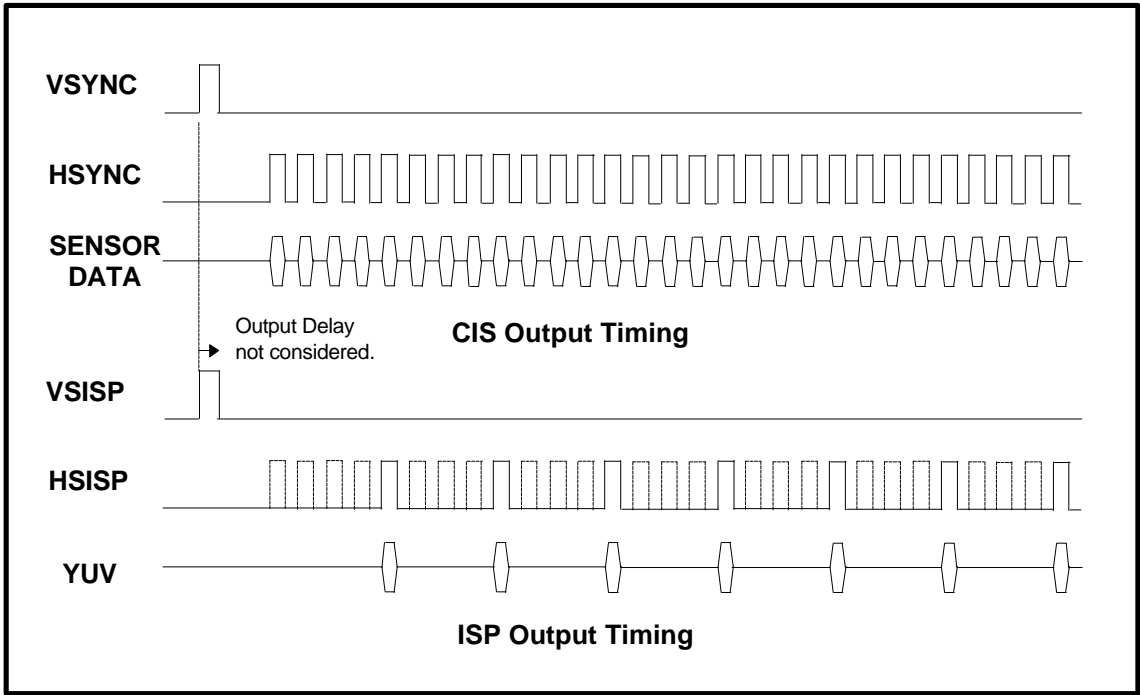
7.4.3. SIF



7.4.4. QCIF



7.4.5. QSIF



8. Register Description

8.1. Registers Mnemonic Table

- BASE Registers Table

Register Name	Mnemonic	Address	Default
Operating Mode Register	OP_MODE	80h	02h
Base Function Enable Register	BASE_ENB	81h	01h
Scale Width Control Upper Register	SCALE_UPPER	82h	01h
Scale Width Control Lower Register	SCALE_LOWER	83h	40h
CMA11 Register	CMA11	8Ah	5Ah
CMA12 Register	CMA12	8Bh	F3h
CMA13 Register	CMA13	8Ch	F3h
CMA21 Register	CMA21	8Dh	F3h
CMA22 Register	CMA22	8Eh	5Ah
CMA23 Register	CMA23	8Fh	F3h
CMA31 Register	CMA31	90h	F3h
CMA32 Register	CMA32	91h	F3h
CMA33 Register	CMA33	92h	5Ah
OFSR Register	OFSR	93h	00h
OFSG Register	OFSG	94h	00h
OFSB Register	OFSB	95h	00h

- AUTO Registers Table

Register Name	Mnemonic	Address	Default
Auto Function Enable Register	AUTO_ENB	A0h	00h
AWB/AE Window Horizontal Start Position Ha	WIN_H_START	A1h	2Dh
Horizontal Side Segment Width Hb	WIN_H_SIDE	A2h	96h
Horizontal Center Segment Width Hc	WIN_H_CENTER	A3h	FAh
AWB/AE Window Vertical Start Position Va	WIN_V_START	A4h	0Ah
Vertical Side Segment Height Vb	WIN_V_SIDE	A5h	50h
Vertical Center Segment Height Vc	WIN_V_CENTER	A6h	0Ah
Analog Gain-Top Limit Register	GAIN_TOP	A7h	3Fh
Analog Gain-Bottom Limit Register	GAIN_BOTTOM	A8h	14h

AWB Function Control Register	AWB_CONTROL	A9h	76h
AWB Lock Control Register	AWB_LOCK	AAh	B5h
AE Function Control Register	AE_CONTROL	ABh	55h
AE Lock Control Register	AE_LOCK	ACH	B5h
Y-target Value Register	Y_TARGET	ADh	80h
Reset Level Control Register	RESET_LEVEL	Aeh	20h
Exposure Time Limitation Value Upper Byte	EXP_LMT_UPPER	B0h	14h
Exposure Time Limitation Value Middle Byte	EXP_LMT_MIDDLE	B1h	58h
Exposure Time Limitation Value Lower Byte	EXP_LMT_LOWER	B2h	55h
AWB Cr-target Value Register	AWB_CR_TARGET	B3h	80h
AWB Cb-target Value Register	AWB_CB_TARGET	B4h	80h
Anti Flicker Unit Time Upper Byte	AF_UT_UPPER	B5h	01h
Anti Flicker Unit Time Middle Byte	AF_UT_MIDDLE	B6h	B2h
Anti Flicker Unit Time Lower Byte	AF_UT_LOWER	B7h	07h
Lock Status Flags Register(Read Only)	STATUS_FLAGS	B8h	XXh

● OUT Registers Table

Register Name	Mnemonic	Address	Default
Edge Control Register	EDGE_CONTROL	C0h	0Dh
Output Format Control Register	OUT_FORM	C1h	08h
HSYNC Counter Register	HSYNC_COUNT	C2h	06h
Manual Histogram Mode Control Register	HISTO_MODE	C3h	00h
Fixed Contrast Stretching Factor Register	FIXED_FACTOR	C4h	00h
Gamma Start 0 Register	GMA_START0	E0h	20h
Gamma Start 1 Register	GMA_START1	E1h	2Dh
Gamma Start 2 Register	GMA_START2	E2h	37h
Gamma Start 3 Register	GMA_START3	E3h	47h
Gamma Start 4 Register	GMA_START4	E4h	5Fh
Gamma Start 5 Register	GMA_START5	E5h	72h
Gamma Start 6 Register	GMA_START6	E6h	83h
Gamma Start 7 Register	GMA_START7	E7h	B6h
Gamma Start 8 Register	GMA_START8	E8h	DEh

Gamma Slope 0 Register	GMA_SLOPE0	E9h	19h
Gamma Slope 1 Register	GMA_SLOPE1	EAh	28h
Gamma Slope 2 Register	GMA_SLOPE2	EBh	1Fh
Gamma Slope 3 Register	GMA_SLOPE3	ECh	18h
Gamma Slope 4 Register	GMA_SLOPE4	EDh	13h
Gamma Slope 5 Register	GMA_SLOPE5	EEh	10h
Gamma Slope 6 Register	GMA_SLOPE6	EFh	0Ch
Gamma Slope 7 Register	GMA_SLOPE7	F0h	09h
Gamma Slope 8 Register	GMA_SLOPE8	F1h	08h

8.2. BASE Register Map

(MCU Address Space 80h~95h)

8.2.1. Normal Register[80h~83h]

Operating Mode Register[80h]

[02h]

[7]	[6]	[5]	[4]		[2]	[1]	[0]
-----	-----	-----	-----	--	-----	-----	-----

[7..6] Sensor PCLK divider [R/W]

0 : MCLK/3, 1: MCLK/6, 2: MCLK/12, 3: MCLK/24

* Note : Normally, use MCLK/3 with VGA(HV7131X), CIF(HV7121X) CIS

[5..4] ISP Clock divider [R/W]

0 : MCLK/3, 1: MCLK/6, 2: MCLK/12, 3: MCLK/24

* Note : Normally, use MCLK/3 with VGA(HV7131X) CIS, MCLK/6 with CIF(HV7121X) CIS

[2..0] Operating Mode Set [R/W]

1 0 0 : VGA (1 to 1 Mode)

0 1 1 : C I F (Subsample Mode)

0 1 0 : S I F (Subsample Mode)

0 0 1 : QCIF (Subsample Mode)

0 0 0 : QSIF (Subsample Mode)

These bits specifies which one of color interpolation methods is used,

VGA : color interpolation using 3x3 spatial kernel

CIF/SIF : color interpolation using 3/4 subsampling using 2x2 kernel

QCIF/QSIF : color interpolation using 3/16 subsampling using 4x4 kernel
and also specifies which one of input image size scalings is used.

VGA : 1/1 scaling

CIF/SIF : 1/4 scaling

QCIF/QSIF : 1/16 scaling

a) Subsampling mode definitions

3/4 subsampling : 2x2 Bayer Data for four sensor pixels.

⇒ R/G/B Data for a output pixel in CIF/SIF mode.

Subsampling window moves by 2 pixels in horizontal
and vertical directions.

3/16 subsampling : 4x4 Bayer Data for sixteen sensor pixels.

⇒ R/G/B Data for a output pixel in QCIF/QSIF mode.

Subsampling window moves by 4 pixels in horizontal
and vertical directions.

b) In VGA(1 to 1 Mode) mode operation, ISP needs the input image with 642 X 482 size for horizontal and vertical interpolation. In CIF,SIF,QCIF,QSIF (Subsample Mode) mode operation, ISP needs the input image with 640 X 482 for vertical interpolation. The reason that vertical height is two lines plus 480 is that internal ISP logic requires two lines timing margin to support CIF/QCIF/X-flip functions. For CIF mode, horizontal blank period of a sensor must be larger than 64 pixel clock.

Base Function Enable Register[81h]**[01h]**

		[5]	[4]	[3]	[2]	[1]	[0]
[5]	RB Interpolation Mode Set						[R/W]
	Two R/B color interpolation methods are supported when R or B color component is interpolated from neighbor pixels's information for full RGB color in VGA mode:						
	a) average mode that interpolates missing R or B by just averaging neighbor R or B pixels,						
	b) chromacity mode that interpolates missing R or B from utilizing neighbor chromacitis values, (R-G) or (B-G).						
	This bit specifies which one of the color interpolation methods is used						
	1 : Average, 0 : Chromacity						
[4]	G Interpolation Mode Set						[R/W]
	Two G color interpolation methods are supported when G color component is interpolated from neighbor G pixels's information for full RGB color in VGA mode:						
	a) median mode that interpolates missing G by averaging median neighbor G values excluding maximum/minimum neighbor G values.						
	b) average mode that interpolates missing G by averaging all neighbor G values.						
	This bit specifies which one of G color interpolation methods is used						
	1 : Median, 0 : Average						
[3]	X-Flip Function Enable						[R/W]
	The function enables the horizontal flip(left-right changed) of input image data. In oder to get the flipped standard image size(640x480) with VGA interpolation mode selected, input image data input size should be 642x483 that height size is one more line increased, to account for Bayer input data to be flipped before any processing proceeds.						
	For other flipped image size format outputs(CIF/SIF/QCIF/QSIG), the input image size is the same as that for unflipped image data out, 640x482.						
	1: X-Flip ON, 0 : X-Flip OFF						
[2]	Gamma Function Enable						[R/W]
	Piecewise linear gamma approximation method is implemented. Precise piece linear segments are supported and user-programmable.						
	For more details, refer to gamma register description section.						
	1 : Gamma ON, 0 : Gamma OFF						
[1]	Color Matrix Function Enable						[R/W]
	This function compensates color spread effect of color filters and sensing circuits to get the optimal pure color reproduction. color matrix coefficients are programmable from -127/64 to 127/64. Offset compensation registers are also supported.						
	1 : Color Matrix ON, 0 : Color Matrix OFF						

- [0] Color Interpolation Function Enable [R/W]
 This bit specifies whether color interpolation is processed or not. Color interpolation methods are defined by OP_MODE register. Most importantly, in order to have a correct color interpolation, the first input pixel data type should be R pixel data.
 1 : Interpolation ON, 0 : Interpolation OFF

* Note : The start pixel of every input frame must be R for proper interpolation.

Scale Width Control Upper Register[82h]

[01h]

							[0]
--	--	--	--	--	--	--	-----

- [0] Scale Width Control Upper Value [R/W]

Scale Width Control Lower Register[83h]

[40h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

- [7..0] Scale Width Control Lower Value [R/W]

* Note : The scale width control register is only related to operating mode CIF/SIF/QCIF/QSIF, and controls how many column data in each line are output. Default value is 140h(340d), the half of standard VGA width size.

8.2.2. Color Matrix Coefficients Value[8Ah ~ 95h]

These registers are used in color matrix function in order to compensates color spread effect of color filters and sensing circuits to get the optimal pure color reproduction. Color matrix coefficients are programmable from -127/64 to 127/64. Programming register value for intended color matrix coefficients should be resolved by the following sequence.

For positive values,

$$CMA_{xx} = \text{Integer}(\text{RealCoefficientValue} \times 64);$$

For negative values,

$$CMA_{xx} = \text{TwosComplement}(\text{Integer}(\text{RealCoefficientValue} \times 64));$$

RealCoefficientValue values from -127/64 to 127/64 can be programmed.

Offset compensation registers are also supported.

- Fundamental color matrix equation

$$\begin{bmatrix} CMA11 & CMA12 & CMA13 \\ CMA21 & CMA22 & CMA23 \\ CMA31 & CMA32 & CMA33 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} + \begin{bmatrix} OFSR \\ OFSG \\ OFSB \end{bmatrix}$$

CMA11 Register[8Ah]**[5Ah]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] CMA11 Value X 64 2's Complement

[R/W]

CMA12 Register[8Bh]**[F3h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] CMA12 Value X 64 2's Complement

[R/W]

CMA13 Register[8Ch]**[F3h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] CMA13 Value X 64 2's Complement

[R/W]

CMA21 Register[8Dh]**[F3h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] CMA21 Value X 64 2's Complement

[R/W]

CMA22 Register[8Eh]**[5Ah]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] CMA22 Value X 64 2's Complement

[R/W]

CMA23 Register[8Fh]**[F3h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] CMA23 Value X 64 2's Complement

[R/W]

CMA31 Register[90h]**[F3h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] CMA31 Value X 64 2's Complement

[R/W]

CMA32 Register[91h]**[F3h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] CMA32 Value X 64 2's Complement

[R/W]

CMA33 Register[92h]**[5Ah]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] CMA33 Value X 64 2's Complement

[R/W]

OFSR Register[93h]**[00h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] Color Matrix Red Offset Value -127 ~ +128 2's complement

[R/W]

OFSG Register[94h]**[00h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] Color Matrix Green Offset Value -127 ~ +128 2's complement

[R/W]

OFSB Register[95h]**[00h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] Color Matrix Blue Offset Value -127 ~ +128 2's complement

[R/W]

* Note : The values of CMA11~CMA33 are allowed between -2 and 2

8.3. AUTO Register Map

(MCU Address Space A0h ~ B4h)

8.3.1. Function Enable Register[A0h]

Auto Function Enable Register[A0h]						[00h]	
[7]	[6]	[5]	[4]	[3]		[1]	[0]
[7]	Image Sensor ENB Control						[R/W]
	1 : ENB enable, 0 : ENB disable						
[6]	AE Mode Control 1						[R/W]
	Used with AE mode control 0 at bit 0						
[5]	Auto Histogram Equalization Enable						[R/W]
	Automatically enables the histogram equalization function when larger exposure time than exposure time limit value defined at the registers B0 ~ B2 is needed to achieve Y target brightness. This bit is not valid when manual histogram equalization defined at register C3h is enabled.						
	1 : Auto Histogram Equalization ON						
	0 : Auto Histogram Equalization OFF						
[4]	Automatic Reset Level Control						[R/W]
	Automatically controls the Reset Level of CMOS Image Sensor. Low Reference Count Register and High Reference Count Register (Hyundai CMOS Image Sensor Registers, Addressed 57h 58h 59h 5ah) denote the current sampling condition. when the ARC function enable, ARC logic reads these register values and compares with the threshold value within the Reset Level Control Register(ISP Register Addressed AEh). If the low reference count or high reference count is larger than the value of Reset Level Control Register, ARC Logic considers Reset Level is not suitable for fine sampling, and update the appropriate Reset Level Value in the Reset Level Register(30h) of HYUNDAI CMOS Image Sensor.						
	1 : ARC on, 0 : ARC off						
[3]	Automatic G-color gain Control						[R/W]
	AWB Logic control only the R, B color gain of CIS. So, for getting better color balance and using large analog gain range, G color gain must be controlled. If this function(AGC) is enabled, AGC Logic control appropriate G-color gain level automatically. It may be disabled, when the analog gain range(Limited by analog gain Top, Bottom Limit Register) is too small.						
	1 : AGC on, 0 : AGC off						

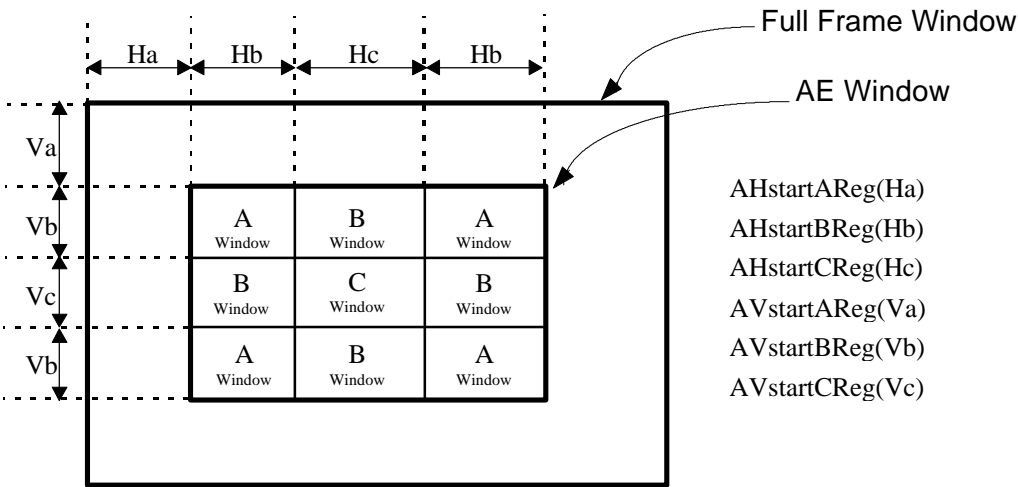
[1]	AWB Function Control	[R/W]
	1 : AWB On, 0 : AWB Off	
[0]	AE Mode Control 0	[R/W]
	Define AE mode with AE mode control 1 at bit 6	

AE mode control 1	AE mode control 0	AE mode
0	0	AE disable
0	1	AE pixel mode
1	X	AE anti-flicker mode

8.3.2. AWB/AE Windows Configuration Registers[A1h~A6h]

Hyundai H1A424M167 analyze the input image from the CMOS Image Sensor, base on the 9 programmable windows for AE and AWB. The AE and AWB function use Y and U,V values from 9 independent windows to adjust brightness and to correct color balance.

● AWB/AE Windows Configuration



AWB/AE Window Horizontal Start Position Ha [A1h] [2Dh]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
[7..0] A-Windows Horizontal Size Pixel Count Value							[R/W]

Horizontal Side Segment Width Hb [A2h] [96h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
[7..0] B-Windows Horizontal Size Pixel Count Value							[R/W]

Horizontal Center Segment Width Hc [A3h]**[FAh]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] C-Windows Horizontal Size Pixel Count Value

[R/W]

AWE/AE Window Vertical Start Position Va [A4h]**[0Ah]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] A-Windows Vertical Size Pixel Count Value

[R/W]

Vertical Side Segment Height Vb [A5h]**[50h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] B-Windows Vertical Size Pixel Count Value

[R/W]

Vertical Center Segment Height Vc [A6h]**[0Ah]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] C-Windows Vertical Size Pixel Count Value

[R/W]

* Note : When the display mode is not VGA, Horizontal Configuration value (Ha, Hb, Hc) have to be programmed as two times larger value of actual Horizontal display size.

8.3.3. Normal Register[A7h~B8h]**Analog Gain-Top Limit Register[A7h]****[3Fh]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] Analog Gain-Top Value(Analog Gain Level Boundary)

[R/W]

Analog Gain-Bottom Limit Register[A8h]**[14h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] Analog Gain-Bottom Value(Analog Gain Level Boundary)

[R/W]

CMOS Image Sensor supports analog gain function to amplify the pixel analog output of CMOS Sensor. Available programmable range is 0 - 63. If the analog gain is too large or too small, the dynamic range of sensor pixel output is not suitable for fine scene. These registers(A7h,A8h) define the usable analog gain range (maximum and minimum gain) of CIS for ISP to control R,G,B gain of CMOS Image Sensor within this range. Available programmable range is 0 - 63 and the value of analog gain-Top limit register must be larger than the value of analog gain-Bottom Limit register.

AWB Function Control Register[A9h]**[76h]**

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

This Register is used to define the pixels to be accumulated for AWB. Only the pixels

within the defined color and luminous range on this register will be used for AWB.

[7. .5] Cr+Cb Range Selector [R/W]

[4. .2] Cr Range Selector [R/W]

* Note : 0 to 7 are allowed for Cr+Cb range and Cr range.

Larger value means wider AWB white spot.

[1] Luminous Range selector [R/W]

1 : Reject too Dark and too Bright pixels for AWB

0 : Use all pixels for AWB

[0] AwbWin [R/W]

0 : Whole 9 AWB windows used

1 : Only center AWB window used

AWB Lock Control Register[AAh]

[B5h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

This Register is used for AWB Lock Control. The difference between Cr/Cb target and current frame Cr/Cb mean is used for AWB lock/unlock scheme. As the difference is smaller, we can get the good white balanced image. The difference is compared with AWB lock range value and AWB unlock range value. If current state is out of white balance, AWB logic change the R/B gains of CMOS Image Sensor to make the difference less than the lock range value. If the difference is less than lock range value, we consider white balance is achieved and no more gain control made. After getting white balanced image we have to compare the difference with unlock range value to check the image is out of white balance or not. If the difference is larger than the unlock range value, AWB logic start to change R/B gains again to find new white balance point.

[7] AWB Lock_Unlock Function Enable Bit [R/W]

0 : Lock, Unlock Function Disable. In this case AWB Unlock Range is used for both Locking and unlocking. AWB lock range is not used.

1 : Lock, Unlock Function Enable. In this case AWB lock range and AWB unlock range are defined separately for locking and unlocking.

[6..4] AWB Lock Range

[3..0] AWB Unlock Range

* Note : When AWB lock_unlock function is enabled, AWB unlock range have to be larger than the lock range. As the larger value of lock/unlock range, we can get the stable image. And as the small value of lock/unlock range, we can get the fine white balanced image.

● Windows Defined for AE

a	b	a
b	c	b
a	b	a

AE Function Control Register[ABh]

[55h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..6] Weight Mode

[R/W]

These Bits are used to select weight mode of AE Function. When block weight mode is selected, nine AE windows have different weight. When window weight mode is selected, nine AE windows have same weight and all the pixels in the center window(window-c) and window-b will be used for AE but pixels in the window-a are limited by bit 4 Wweight. When block and window mixed mode, AE windows have different weights and pixel limit function is on too by bit 4 Wweight. When Weightless mode is selected, all the original pixel value in the nine AE windows will be used for AE.

00 : Bweight(Block weight) Mode only.

01 : Wweight(Window weight) Mode only.

10 : BWeight + Wweight

11 : Weightless Mode

[5] Bweight

[R/W]

Two kinds of Block Weight are available when Block weight mode.

0 : Smaller center window weight (a < b < c)

1 : Larger center window weight (a < b << c)

[4] Wweight

[R/W]

Windows Weight Selector for AE when Wweight Mode Valid.

0 : Larger Y range is used.

1 : Smaller Y range is used.

[3..2] Anti_Flicker_Control (Lock Range Selector)

[R/W]

Lock range select for Anti-flicker mode. Small value means fine AE control but unstable , large value means rough AE control but stable.

[1] Histogram Equalization Fine Control

[R/W]

This bit defines the Histogram Equalization method when the Histogram Equalization function is on(Auto Function enable Register[5] = 1).

0 : Use small contrast stretching value

1 : Use large contrast stretching value

[0] Exposure Time update rate control.

[R/W]

This bit is used to set the exposure time update rate.

0 : Every 2-frame.

1 : Every 3-frame.

AE Lock Control Register[ACh]

[B5h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

This Register is used for AE Lock Control. The difference between Y target and current frame Y mean is used for AE lock/unlock scheme. As the difference is smaller, we can get the close brightness we want. The difference is compared with AE lock range value and AE unlock range value. If current state is out of target brightness, AE logic change the integration time of CIS to make the difference less than the lock range value. If the difference is less than lock range value, we consider exposure target is achieved and no more integration time control made. After getting target brightness we have to compare the difference with unlock range value to check the image is out of target brightness or not. If the difference is larger than the unlock range value, we have to change integration time again to adjust frame brightness. This register is valid only when AE pixel mode is enabled.

[7] AE Lock_Function Enable Bit

[R/W]

0 : Lock, Unlock Function Disable. In this case, AE Unlock Range is used for all locking and unlocking. AE lock range is not used.

1 : Lock, Unlock Function Enable. In this case, AE lock range and AE unlock range are used for locking and unlocking each.

[6..4] AE Lock Range

[3..0] AE Unlock Range

Y-target Value Register[ADh]

[80h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] AE Target Luminous Value Register.

[R/W]

Reset Level Control Register[A Eh]

[20h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

[7..0] Threshold Pixel Count Value of the Invalid Reference Value.

[R/W]

This Register is used to set the maximum Invalid Pixel Count, produced from CIS sampling(data Read). So, as the small value of this Register, we can get the fine scene. This register valid only when ARC Function(A0h[4]) is enabled.

Exposure Time Limitation Value Upper Byte[B0h]

[14h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Exposure Time Limitation Value Middle Byte[B1h] [58h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Exposure Time Limitation Value Lower Byte[B2h] [55h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

These three Exposure Time Limitation Value Registers(24Bits) are used to set the minimum Frame-Rate. It defines maximum exposure time that can be programmed to CIS integration time registers. And, It must be programmed as multiple of Anti Flicker Unit Time Register(24Bits) when AE anti_Flicker mode is enabled.

AWB Cr-target Value Register[B3h] [80h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

AWB Cb-target Value Register[B4h] [80h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

These Cr, Cb-target Registers are used for controlling Frame Color. AWB logic use these values for a white balance matching. To make a frame reddish, Increase the Cr target register value over 80h or decrease the Cb target register value under 80h.

Anti Flicker Unit Time Upper Byte[B5h] [01h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Anti Flicker Unit Time Middle Byte[B6h] [B2h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Anti Flicker Unit Time Lower Byte[B7h] [07h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Anti Flicker Unit Time Registers(24Bits) should be used to define the time step of changing integration time register. AE Anti-Flicker mode is used to remove horizontal banding noise under fluorescent lamp. When **AE anti-flicker mode is enabled**, the integration registers of a CIS are programmed as multiple of this unit time. These registers are valid only when AE anti-flicker mode is enabled. When **AE pixel mode is enabled**, Anti flicker Unit time Registers(24Bits) are used to set exposure time bottom limitation.

Lock status Flags Register[B8h]

[R-O]

					[2]	[1]	[0]
--	--	--	--	--	-----	-----	-----

User can read the current AE/AWB status using this register.

This register can be used to choose a fine image for digital still camera application.

- | | | |
|-------|--------------------------------------|-------------|
| [2] | Automatic Stretching Status Flag | [Read Only] |
| | 0 : Automatic Stretching is Disable. | |
| | 1 : Automatic Stretching is Enable. | |
| [1] | AWB Lock Status Flag | [Read Only] |
| | 0 : Current AWB status is Unlock. | |
| | 1 : Current AWB status is Lock. | |
| [0] | AE Lock Status Flag | [Read Only] |
| | 0 : Current AE status is Unlock. | |
| | 1 : Current AE status is Lock. | |

8.4. OUT Register Map

(MCU Address Space C0h ~ F1h)

8.4.1. Normal Register[C0h~C2h]

Edge Control Register[C0h]

[0Dh]

				[3]	[2]	[1]	
--	--	--	--	-----	-----	-----	--

[3] 1 : Edge Function Enable, 0 : Edge Function Disable [R/W]

[2] 1 : Use Edge Transfer Function, 0 : Bypass Edge Transfer Function[R/W]

[1]	Edge detection filter select	[R/W]
-------	------------------------------	-------

1: $-1/2, 0, 1, 0, -1/2$

0: 0, -1/2, 1, 0, -1/2

Output Format Control Register[C1h]

[08h]

		[5]	[4]	[3]	[2]	[1]	[0]
--	--	-----	-----	-----	-----	-----	-----

[5]	0 : Use CCIR-601 Color Space Conversion equation	[R/W]
-------	--	-------

1 : Use JFIF Color Space Conversion equation

* Note : Color Space Conversion Equation

- **CCIR 601**

$$Y = \frac{77R + 150G + 29B}{256} \quad \text{Range: 16 ~ 235}$$

$$Cb = \frac{-44R - 87G + 131B}{256} + 128 \quad \text{Range: } 16 \sim 240$$

$$Cr = \frac{131R - 110G - 21B}{256} + 128 \quad \text{Range: } 16 \sim 240$$

- **Reverse CCIR 601**

$$R = Y + 1.336(Cr - 128) - 0.002(Cb - 128)$$

$$G = Y - 0.700(Cr - 128) - 0.334(Cb - 128)$$

$$B = Y - 0.006 (Cr - 128) + 1.732 (Cb - 128)$$

- **CCIR 601-256 [JFIF]**

$$Y = \frac{77R + 150G + 29B}{256}$$

$$Cb = \frac{-43R - 85G + 128B}{256} + 128$$

$$Cr = \frac{128R - 107G - 21B}{256} + 128$$

● **Reverse CCIR 601-256[JFIF]**

$$R = Y + 1.402(Cr - 128)$$

$$G = Y - 0.34414(Cb - 128) - 0.71414(Cr - 128)$$

$$B = Y + 1.772(Cb - 128)$$

- [4..3] 10 : YUV 4:2:2 [R/W]
 11 : YUV 4:2:0
 00, 01 : Don't Care
- [2] 0 : 16bits YCrCb when 4 : 2 : 2 or 4 : 2 : 0 [R/W]
 1 : 8bits YCrCb when 4 : 2 : 2 or 4 : 2 : 0
- [1] 0 : Y first when 8bits YCrCb [R/W]
 1 : CrCb first when 8bits YCrCb
- [0] 0 : Cr first when YCrCb 4 : 2 : 2 or 4 : 2 : 0 [R/W]
 1 : Cb first when YCrCb 4 : 2 : 2 or 4 : 2 : 0

* Note : 8bits output format function cannot be guaranteed.(under testing)

HSYNC Counter Register [C2h]

[06h]

			[4]	[3]	[2]	[1]	[0]
--	--	--	-----	-----	-----	-----	-----

This Register should be used to program the HSYNC Count during Vertical retrace Time. This register defines number of lines for VSYNC pulse to be extended. Some video signal processing chips like Winbond W9967, need VSYNC period as multiple of line period. To support these chips with HYUNDAI CMOS Image Sensor, this register have to have non-zero value.

- [4..0] HSYNC Counter Value (0 ~ 31) [R/W]

8.4.2. Histogram Equalization Control Register[C3h~C4h]

Manual Histogram Mode Control Register[C3h]

[00h]

				[3]	[2]	[1]	[0]
--	--	--	--	-----	-----	-----	-----

- [3] Manual Histogram Function [R/W]
 1 : Manual Histogram equalization enable. If enabled, all the Y values of the pixels are stretched with fixed contrast stretching factor defined at register C4. In this case, auto histogram equalization function dose not work.
 0 : Manual histogram equalization disable. In this case, histogram function is affected by auto histogram equalization function.
- [2 ..1] Knee point select [R/W]

Increasing this value move knee point toward 0. Decreasing this value move knee point toward 255. Valid when knee function is enabled.

[0] Knee Function Enable. [R/W]
0 : Disable 1: Enable.

Fixed Contrast Stretching Factor Register[C4h] [00h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

This register is used for manual contrast stretching function. Program value should be multiplied stretching Factor by 32(decimal) for the Reducing Rounding Error.

Stretching Factor can be 0 ~ 8.

8.4.3. Gamma Control Register[E0h~F1h]

Gamma Start0 ~ Start8 Register[E0h~E8h]

Gamma Slope0 ~ Slope8 Register[E9h~F1h]

Piecewise linear gamma approximation method is implemented. Nine piece linear segments are supported and user-programmable.

Gamma Slope Register[E8h] value has effect scaled by 1/8

Gamma Slope Registers[E9h-F1h] value has effect scaled by 1/16

Gamma Start 0 Register[E0h] [20h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Gamma Start 1 Register[E1h] [2Dh]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Gamma Start 2 Register[E2h] [37h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Gamma Start 3 Register[E3h] [47h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Gamma Start 4 Register[E4h] [5Fh]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Gamma Start 5 Register[E5h] [72h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Gamma Start 6 Register[E6h] [83h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Gamma Start 7 Register[E7h] [B6h]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Gamma Start 8 Register[E8h] [DEh]

[7]	[6]	[5]	[4]	[3]	[2]	[1]	[0]
-----	-----	-----	-----	-----	-----	-----	-----

Gamma Slope 0 Register[E9h] [19h]

	[6]	[5]	[4]	[3]	[2]	[1]	[0]
--	-----	-----	-----	-----	-----	-----	-----

Gamma Slope 1 Register[EAh] [28h]

	[6]	[5]	[4]	[3]	[2]	[1]	[0]
--	-----	-----	-----	-----	-----	-----	-----

Gamma Slope 2 Register[EBh] [1fh]

	[6]	[5]	[4]	[3]	[2]	[1]	[0]
--	-----	-----	-----	-----	-----	-----	-----

Gamma Slope 3 Register[ECh] [18h]

	[6]	[5]	[4]	[3]	[2]	[1]	[0]
--	-----	-----	-----	-----	-----	-----	-----

Gamma Slope 4 Register[EDh] [13h]

	[6]	[5]	[4]	[3]	[2]	[1]	[0]
--	-----	-----	-----	-----	-----	-----	-----

Gamma Slope 5 Register[EEh] [10h]

	[6]	[5]	[4]	[3]	[2]	[1]	[0]
--	-----	-----	-----	-----	-----	-----	-----

Gamma Slope 6 Register[EFh] [0Ch]

	[6]	[5]	[4]	[3]	[2]	[1]	[0]
--	-----	-----	-----	-----	-----	-----	-----

Gamma Slope 7 Register[F0h] [09h]

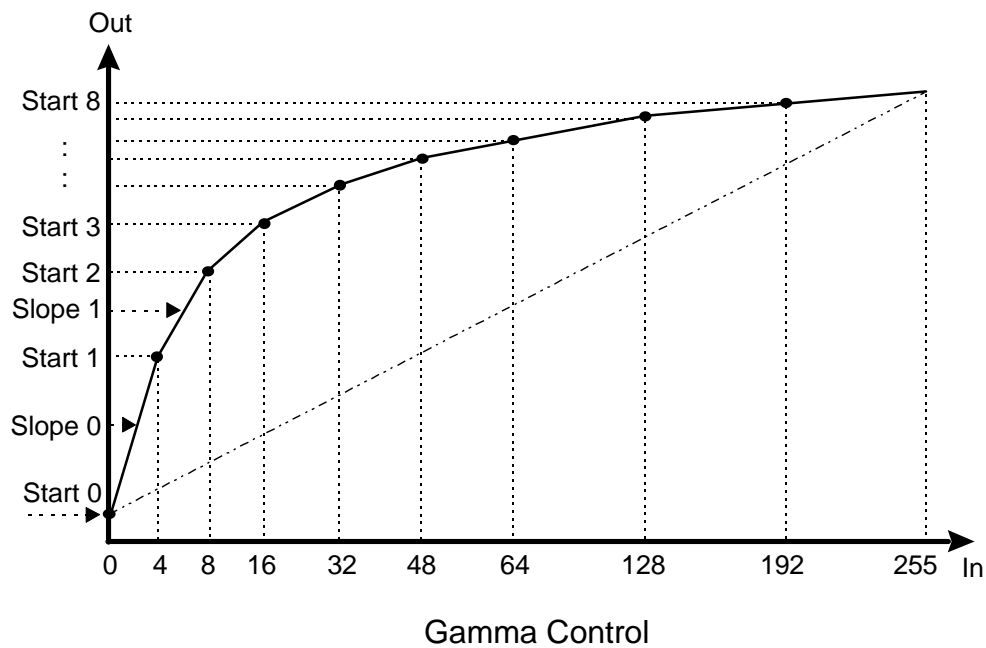
	[6]	[5]	[4]	[3]	[2]	[1]	[0]
--	-----	-----	-----	-----	-----	-----	-----

Gamma Slope 8 Register[F1h]**[08h]**

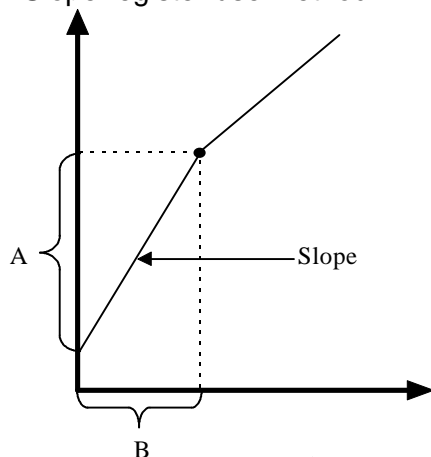
	[6]	[5]	[4]	[3]	[2]	[1]	[0]
--	-----	-----	-----	-----	-----	-----	-----

* Note : Gamma Slope Registers Should be Programmed as Multiple of 8 or 16 with real slope value for reducing rounding error. For the Slope 0 Register, Using 8 and Others Using 16.

- Gamma graph define



- Slope register use method



$$\text{Slope} = \left(\frac{A}{B} \right)$$

⇒ Slope Register Value = Slope × P

⇒ P = 8 (at Slope 0 Register)

P = 16 (at others Slope Register)

9. Electrical Characteristics

9.1. Absolute Maximum Ratings

Symbol	Parameter	Min.	Max	Unit
T _{AMB}	Operating ambient temperature	0	70	°C
T _{STG}	Storage temperature	-40	125	°C
V _{DD}	3.3V DC supply voltage	3.0	3.6	V
IO _{DD}	I/O pin voltage with respect to V _{SS}	-0.3	V _{DD} + 0.3	V
P _{TOT}	Total power dissipation	-	182	mW
V _I	Input voltage	-0.3	V _{DD} + 0.3	V
V _O	Output voltage	-0.3	V _{DD} + 0.3	V

9.2. DC Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I _{DD}	Supply current	all modes on	-	39	55.2	mA
		all modes off	13.5	-	-	mA
MCLK	Master Clock	-	-	36	48	MHz
V _{IL}	Low level input voltage		-	-	0.8Vmax	V
V _{IH}	High level input voltage		2.1Vmin	-	-	V
V _{OL}	Low level output voltage		-	-	0.4	V
V _{OH}	High level output voltage		2.4	-	-	V

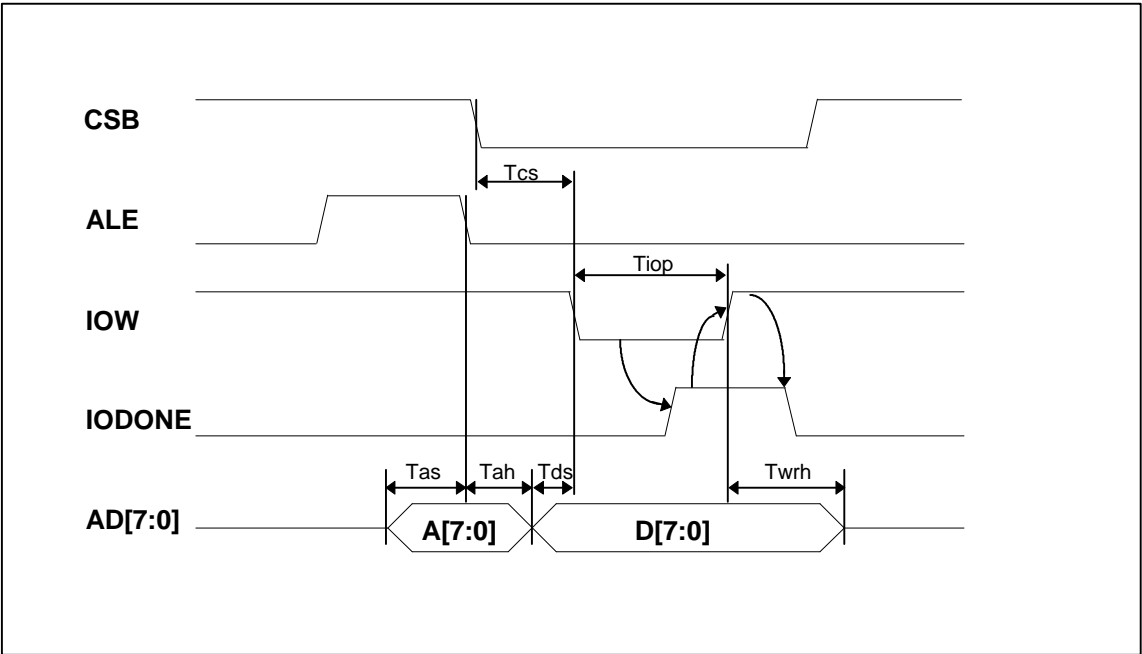
* Test condition

V_{DD} = 3.3V, Temperature = 25 °C; Output load = 10pF; MCLK : 36MHz

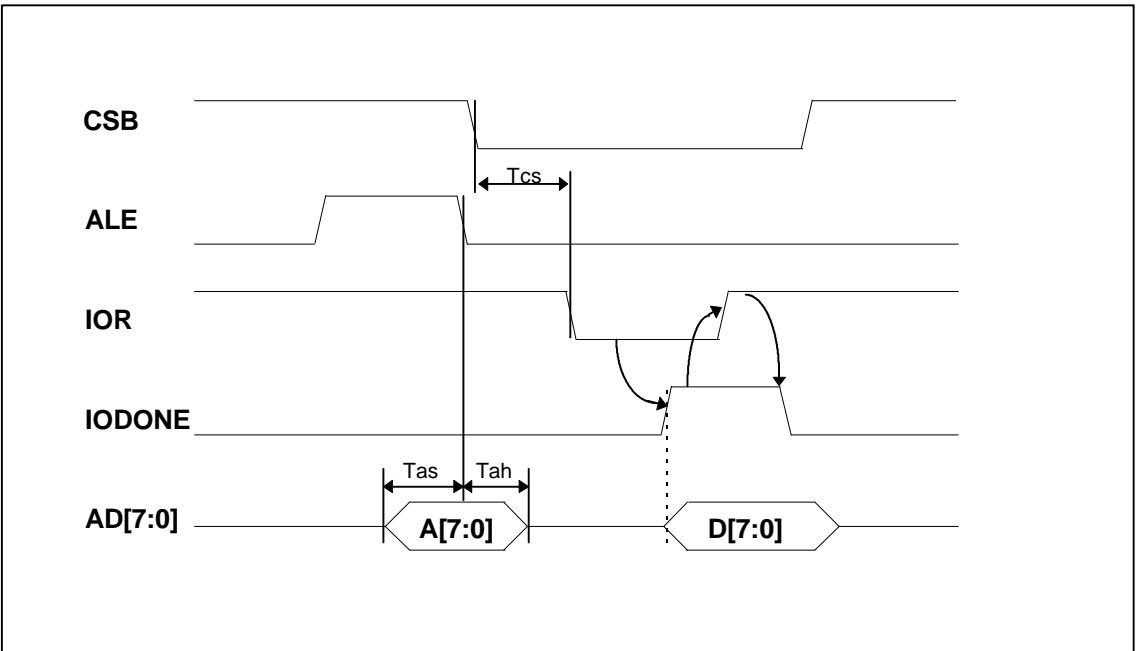
unless otherwise specified.

9.3. AC Characteristics

9.3.1. Microcontroller Bus Interface timing (Write cycle)



9.3.2. Microcontroller Bus Interface timing (Read cycle)

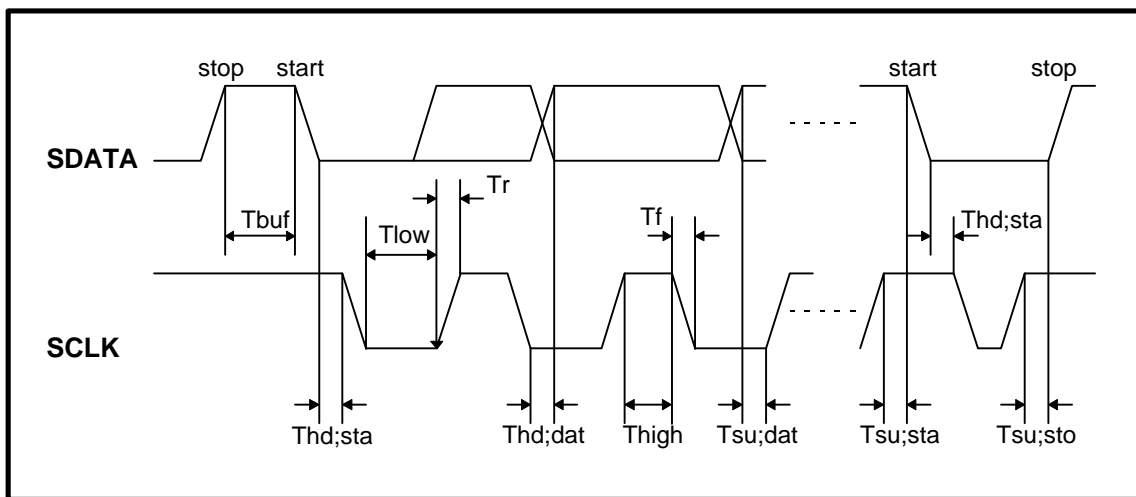


● Microcontroller Bus Timing

Time	Description	Min	Typ	Max	Units
Tcs	Chip Select setup time	0	-	-	ns
Tas	Address setup time	10	-	-	ns
Tah	Address hold time	5	-	-	ns
Twrh	Write data hold time	5	-	-	ns
Tiop	IOW,IOR period time	1	-	-	⁽¹⁾ clk
Tds	Data setup time	5	-	-	ns

(1) This is ISP Clock ; Typically, MCLK/3(VGA CIS), MCLK/6(CIF CIS)

9.3.3. Serial Interface Control Timing

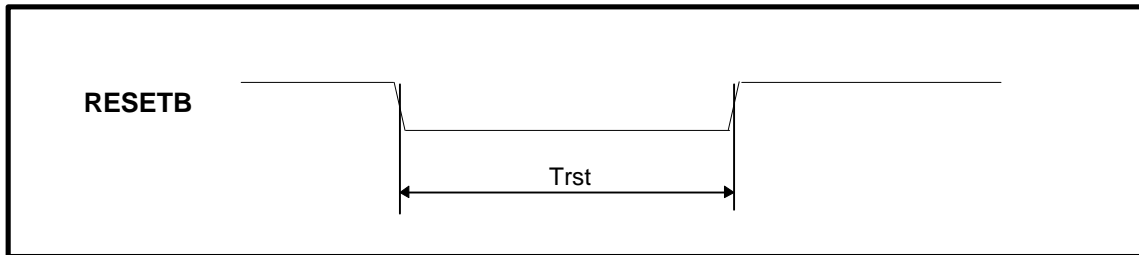


● Serial Interface Timing

Time	Description	Min	Typ	Max	Units
Fscl	SCL clock frequency	0	-	400	KHz
Tbuf	Bus free time between a STOP and START condition	1.3	-	-	μs
Thd;sta	Hold time START condition	0.6	-	-	μs
Tlow	LOW period of the SCL clock	1.3	-	-	μs
Thigh	HIGH period of the SCL clock	0.6	-	-	μs
Tsu;sta	Setup time for a repeated START condition	0.6	-	-	μs
Thd;dat	Data hold time	0	-	0.9	μs
Tsu;dat	Data setup time	100	-	-	ns
Tr	Rise time of both SDA and SCL signals	20 + 0.1Cb	-	300	ns

Tf	Fall time of both SDA and SCL signals	20 + 0.1Cb	-	300	ns
Tsu;sto	Setup time for STOP condition	0.6	-	-	μs
Cb	Capacitive load for each bus line	-	-	400	pF

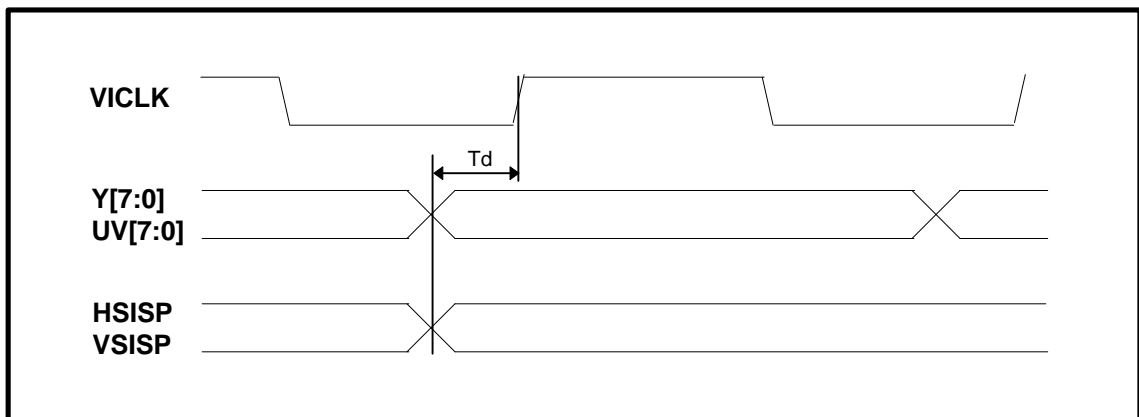
9.3.4. RESETB Timing



● RESETB Timing

Time	Description	Min	Typ	Max	Units
Trst	RESETB pulse width LOW	MCLK * 2	-	-	

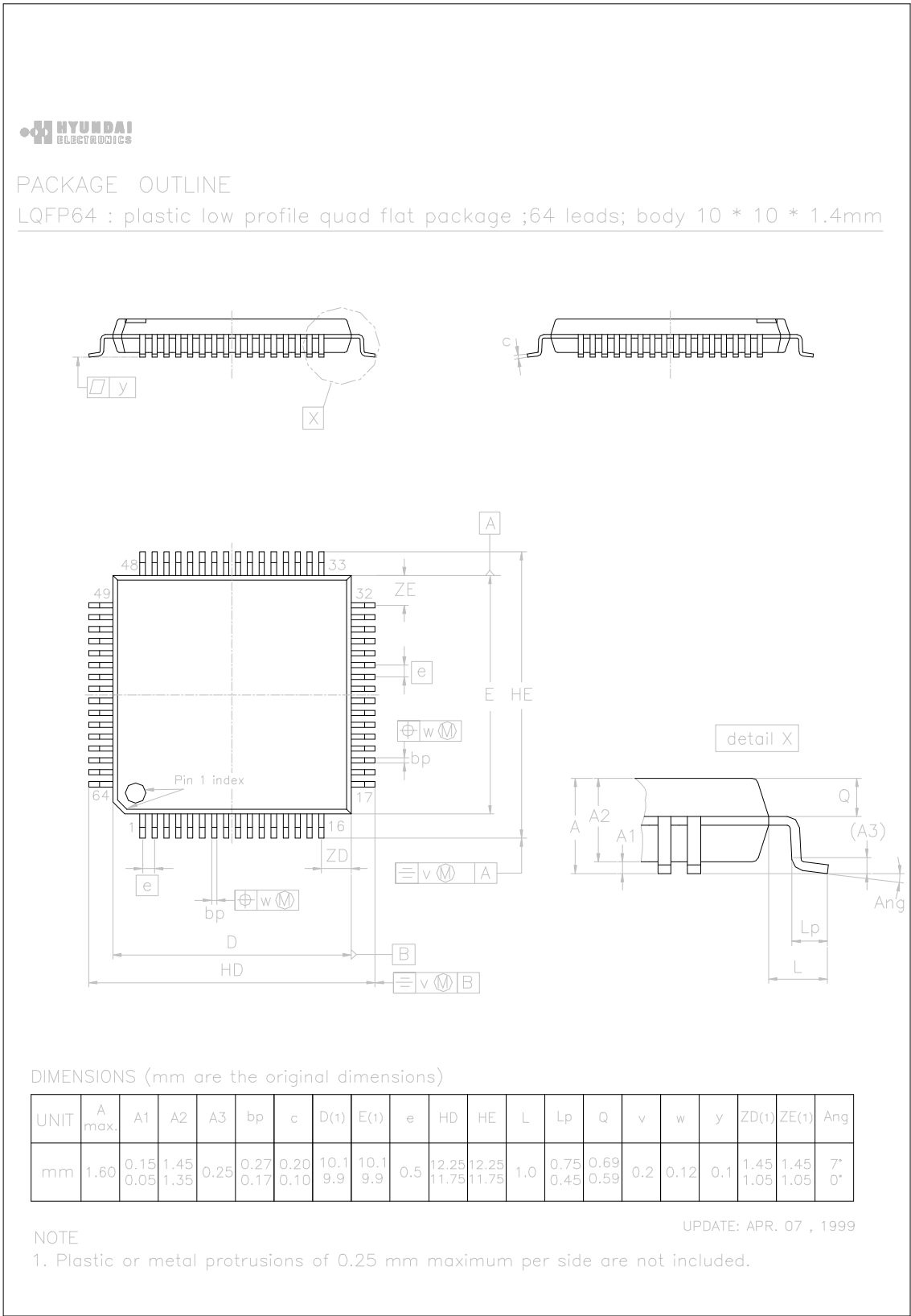
9.3.5. Video Output Timing



● Video Timing

Time	Description	Min	Typ	Max	Units
Td	Video output delay time	-	30	32	ns

10. PACKAGE SPEC



11. SOLDERING

11.1. Solder reflow equipment

11.1.1. (Preferred)100% Convection reflow system capable of maintaining the reflow profiles required by EIA/JEDEC standard(JESD22-A113-B).

11.1.2. VPR(Vapor Phase Reflow) chamber capable of operating from 215 °C - 219 °C and/or (235±5) °C with appropriate fluids.

11.1.3. Infrared(IR)/Convection solder reflow equipment capable of maintaining the reflow profiles required by EIA/JEDEC standard(JESD22-A113-B).

11.2. Reflow Profiles

	Convection or IR/Convection	VPR
Average ramp-up rate(183 °C to Peak)	3 °C/second max.	10 °C/second max.
Preheat temperature 125(±25) °C	120 second max.	
Temperature maintained above 183 °C	60-150 seconds	
Time within 5 °C of actual peak temperature	10-20 seconds	60 seconds
Peak temperature range	(220+5/-0) °C or (235+5/-0) °C	215-219 °C or (235+5/-0) °C
Ramp-down rate	6 °C/second max.	10 °C/second max.
Time 25 °C to peak temperature	6 minutes max.	

11.3. Flux application

After the reflow solder cycles are completed, allow the devices to cool at room ambient for 15 minutes minimum. Apply an activated water soluble flux to the device leads by bulk immersion of the entire parts in flux at room ambient for 10 seconds minimum.

11.4. Cleaning

Clean devices externally using multiple agitated deionized water rinses. No waiting time is required between flux application and cleaning

11.5. Drying

Devices should be dried at room ambient prior to submission to reliability testing.