



NOON300PC51

Version 1.0.4

**3Mega(1/3.2") CMOS Image Sensor
with Image Signal Processor**

Preliminary Specification



Revision History

Version	Date	Comments
1.0.0	2007/03/24	NOON300PC51 Preliminary is released
1.0.1	2007/03/27	Register map are revised.
1.0.2	2007/04/16	Errata are revised.
1.0.3	2007/04/25	Absolute Maximum Ratings table is added.
1.0.4	2007/05/11	Errata are revised.

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1. OVERVIEW

1.1. Description

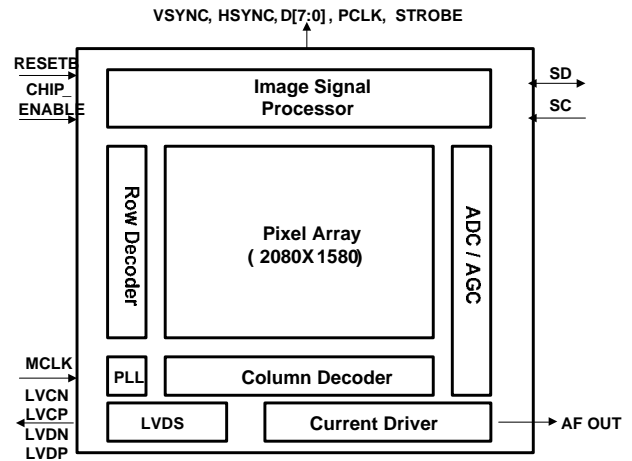
NOON300PC51 is a high quality 3mega-pixel single chip CMOS image sensor for mobile phone camera applications and digital still camera products.

NOON300PC51 incorporates a 2080 x 1580 pixel array, on-chip 10-bit ADC, and an image signal processor. Unique sensor technology enhances image quality by reducing FPN (Fixed Pattern Noise), horizontal/vertical line noise, and random noise.

1.2. Applications

- Mobile Phone Camera / Digital Still Camera
- PC Camera / Video Conference

<Figure 1. Block Diagram>



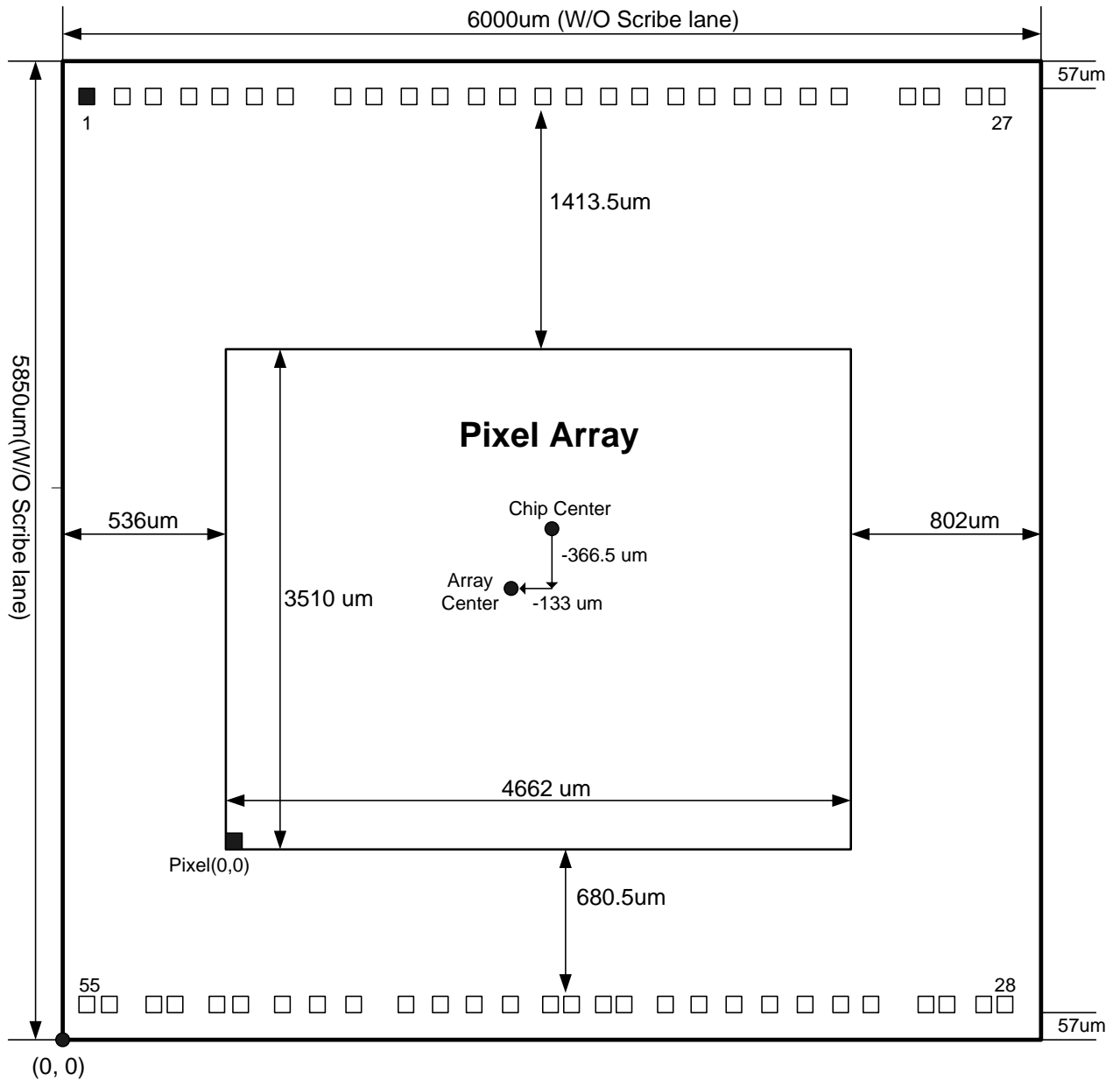
1.3. Key Features

- Pixel Size: 2.25um X 2.25um
- Active Image Size :
4.662mm (H) X 3.510mm(V) X 5.835mm(D)
- Resolution: 2,048H X 1,536V
- Color Filter: RGB Bayer
- Optical Format: 1/3.2 inch
- Sensitivity : TBD @ Green
- Frame Rate: 15fps@QXGA, 30fps@XGA
- Power Supply: 2.8V / 1.5V
- Power Consumption: TBD @ 15fps, QXGA
- ADC: 10bit
- PLL: On Chip
- Operation Temperature: -20 ~ 60°C
- Master Clock: 48MHz(Max)
- Host Interface: two-wire serial bus interface
- Output Format: YUV4:2:2, RGB5:6:5, RGB4:4:4,
ITU656-like
- Edge Data for Auto Focus
- LVDS(Serial Bus) : MIPI, SMIA
- Current Driver for VCM
- Windowing: Programmable
- Sub-Sample: 1/4, 1/16
- Image Scaling : 1x ~ 1/64x
- Image Flip: X/Y Flip
- Auto Exposure
- Auto White Balance
- Anti-Flicker(50Hz / 60Hz): Auto/Manual
- Noise Reduction
- Black Level Calibration
- Strobe Control: Support Xenon / LED Type
- On-Chip Dead Pixel Correction
- Edge Enhancement
- Brightness
- Color Saturation
- Gamma Correction
- Color Correction
- Lens Shading Correction
- Image Effect: Mono, Sepia, Solarization, Negative
Sketch, Embossing



2. CHIP LAYOUT

<Figure 2. Chip Layout>



Pad Open Size in Chip 66um X 66um



[Table 1. PAD Description]

PAD Information (Top side)

Pad No	Pad Name	Description	Location		I/O
			X	Y	
1	VDD:A	Analog Circuit Power Supply Voltage	200	5760	2.8V
2	LV_CN	sub-LVDS Clock – Negative	430	5760	Output
3	LV_CP	sub-LVDS Clock - Positive	610	5760	Output
4	LV_DP	sub-LVDS Data - Positive	840	5760	Output
5	LV_DN	sub-LVDS Data - Negative	1020	5760	Output
6	VDD:P	Analog Pixel Circuit Power Supply Voltage	1250	5760	2.8V
7	VSS:P	Analog Pixel Circuit Ground	1430	5760	GND
8	VDD:D	Digital Core Circuit Power Supply Voltage	1790	5760	1.5V
9	VSS:D	Digital Core Circuit Ground	1970	5760	GND
10	VSS:I	Digital IO Circuit Ground	2200	5760	GND
11	VDD:I	Digital IO Circuit Power Supply Voltage	2380	5760	2.8V
12	MCLK	Master Clock	2610	5760	Input
13	PCLK	Image Data<2> PCLK synchronizes D<7:0>.	2840	5760	Output
14	D<0>	Image Data<0>	3070	5760	Output
15	D<1>	Image Data<1>	3250	5760	Output
16	D<2>	Image Data<2>	3480	5760	Output
17	D<3>	Image Data<3>	3660	5760	Output
18	VDD:I	Digital IO Circuit Power Supply Voltage	3890	5760	2.8V
19	VSS:I	Digital IO Circuit Ground	4070	5760	GND
20	D<4>	Image Data<4>	4300	5760	Output
21	D<5>	Image Data<5>	4480	5760	Output
22	D<6>	Image Data<6>	4710	5760	Output
23	D<7>	Image Data<7>	4890	5760	Output
24	VSS:D	Digital Core Circuit Ground	5300	5760	GND
25	VSS:D	Digital Core Circuit Ground	5400	5760	GND
26	VDD:D	Digital Core Circuit Power Supply Voltage	5580	5760	1.5V
27	VDD:D	Digital Core Circuit Power Supply Voltage	5680	5760	1.5V

**PAD Information (Bottom side)**

Pad No	Pad Name	Description	Location		I/O
			X	Y	
28	VSS:A	Analog Circuit Ground	5780	90	GND
29	VSS:A	Analog Circuit Ground	5680	90	GND
30	VDD:A	Analog Circuit Power Supply Voltage	5500	90	2.8V
31	VDD:A	Analog Circuit Power Supply Voltage	5400	90	2.8V
32	VSS:I	Digital IO Circuit Ground	4850	90	GND
33	VDD:I	Digital IO Circuit Power Supply Voltage	4670	90	2.8V
34	CHIP_ENABLE	CHIP_ENABLE enables sensor. Active High	4440	90	Input
35	RESETB	RESEB initializes sensor. Active Low	4210	90	Input
36	STROBE	Pulse to control strobe circuit in camera system.	3980	90	Output
37	VSYNC	Vertical synchronization	3750	90	Output
38	HSYNC	Horizontal synchronization	3520	90	Output
39	VSS:P	Analog Pixel Circuit Ground	3290	90	GND
40	VSS:P	Analog Pixel Circuit Ground	3190	90	GND
41	VDD:P	Analog Pixel Circuit Power Supply Voltage	3010	90	2.8V
42	VDD:P	Analog Pixel Circuit Power Supply Voltage	2910	90	2.8V
43	D_LSB<1>	Image Data LSB<1>. It is used for 10bit output. When 8bit mode is used, it is possible to disconnect this pad.	2680	90	Output
44	D_LSB<0>	Image Data LSB<0>. It is used for 10bit output. When 8bit mode is used, it is possible to disconnect this pad.	2450	90	Output
45	SD_OUT	Output for Data for two-wire serial interface Additional Output for SD Data for two-wire serial interface Do not connect this pin when serial bus is common with other slave device.	2220	90	Output
46	SD	Data for two-wire serial interface	1990	90	Bi-direction
47	SC	Clock for two-wire serial interface	1630	90	Input
48	VDD:I	Digital IO Circuit Power Supply Voltage	1400	90	2.8V
49	VSS:I	Digital IO Circuit Ground	1220	90	GND
50	VDD:A	Analog Circuit Power Supply Voltage	990	90	2.8V
51	VDD:A	Analog Circuit Power Supply Voltage	890	90	2.8V
52	VSS:A	Analog Circuit Ground	710	90	GND
53	VSS:A	Analog Circuit Ground	610	90	GND
54	AF_OUT	Current driver output for VCM (Auto Focus)	250	90	Output
55	AF_OUT	Current driver output for VCM (Auto Focus)	150	90	Output

3. ELECTRICAL CHARACTERISTICS

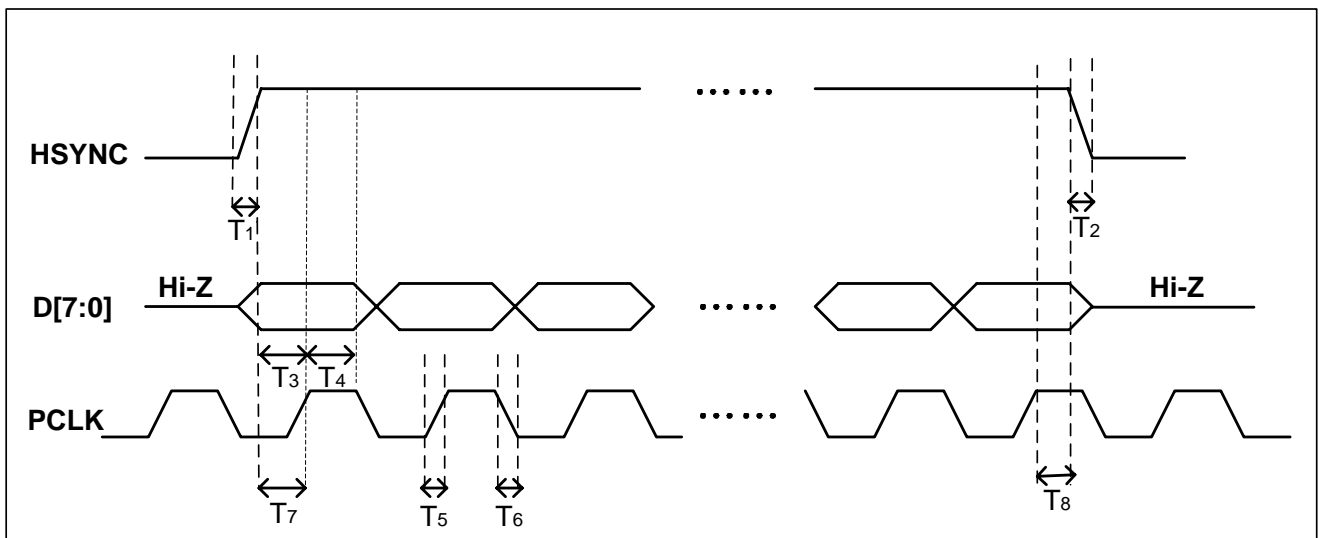
[Table 2. DC Characteristics]

Item	Symbol	Min	Typ	Max	Unit	Note
Digital Core Circuit Power Supply Voltage	$V_{DD:D}$	1.4	1.5	1.6	V	
Analog Circuit Power Supply Voltage	$V_{DD:A}$	2.6	2.8	3.0	V	
Analog Pixel Circuit Power Supply Voltage	$V_{DD:P}$	2.6	2.8	3.0	V	
Digital I/O Circuit Power Supply Voltage	$V_{DD:I}$	1.4		3.0	V	
H level Input Voltage	V_{IH}	$0.7 \cdot V_{DD:I}$			V	
L level Input Voltage	V_{IL}			$0.3 \cdot V_{DD:I}$	V	
Output High Current ($V_{DD:I} = 2.8V, V_{OH} = 2.4V$)	I_{OH}		4.3		mA	1
Output High Current ($V_{DD:I} = 1.5V, V_{OH} = 1.1V$)	I_{OH}		2.4		mA	1
Output Low Current ($V_{DD:I} = 2.8V, V_{OL} = 0.4V$)	I_{OL}		5.5		mA	1
Output Low Current ($V_{DD:I} = 1.5V, V_{OL} = 0.4V$)	I_{OL}		3.8		mA	1

Note1) User can control the amount of current by controlling bit[7:4] of PWRCTL[0x01:P0].

Above values are output current when bit[7:4] of PWRCTL[0x01:P0] is 4'b0101.

<Figure 3. AC Timing of output PAD>



[Table 3. AC Characteristics]

Item	Symbol	Min	Typ	Max	Unit	Note
MCLK	Frequency	12		48	MHz	
MCLK	Duty Cycle	45	50	55	%	
PCLK	Frequency			110	MHz	
PCLK	Duty Cycle	40	50	60	%	
SC	Frequency			400	KHz	
HSYNC(VSYNC) rising time	T_1			4.6	ns	2



HSYNC(VSYNC) falling time	T ₂			3.6	ns	2
PCLK rising time	T ₅			4.6	ns	2
PCLK falling time	T ₆			3.6	ns	2
HSYNC(VSYNC) rising time	T ₁			6.2	ns	3
HSYNC(VSYNC) falling time	T ₂			3.8	ns	3
PCLK rising time	T ₅			6.2	ns	3
PCLK falling time	T ₆			3.8	ns	3
Setup time of PCLK - HSYNC	T ₇	2			ns	
Hold time of PCLK - HSYNC	T ₈	2			ns	
Setup time of PCLK – D[7:0]	T ₃	2			ns	
Hold time of PCLK – D[7:0]	T ₄	2			ns	

Note2) Output load capacitance = 20pF, V_{DD:A} & V_{DD:P}=2.8V, V_{DD:C}=1.5V, V_{DD:I}=2.8V, V_{OH}=2.4V, V_{OL}=0.4V

Note3) Output load capacitance = 20pF, V_{DD:A} & V_{DD:P}=2.8V, V_{DD:C}=1.5V, V_{DD:I}=1.5V, V_{OH}=1.1V, V_{OL}=0.4V

User can control the rising(falling) time by controlling bit[7:4] of PWRCTL[0x01:P0].

Above values are rising(falling) time when bit[7:4] of PWRCTL[0x01:P0] is 4'b0101.

[Table 4 Temperature Characteristics]

Item	Symbol	Rating	Unit	Note
Storage Temperature	T _{STR}	-30 ~ 80	°C	
Functional Operating Temperature	T _{FUN}	-20 ~ 60	°C	Camera fully functional
Optimum Operation Temperature	T _{OPT}	5 ~30	°C	No visible degradation in image quality

[Table 5. Power Consumption]

Item	Condition	Min	Typ	Max	Unit	Note
QXGA @ 15fps	V _{DD:A} & V _{DD:P} =2.8V		TBD		mA	4
	V _{DD:I} =2.8V		TBD		mA	5
	V _{DD:C} =1.5V		TBD		mA	
XGA @ 30fps	V _{DD:A} & V _{DD:P} =2.8V		TBD		mA	4
	V _{DD:I} =2.8V		TBD		mA	5
	V _{DD:C} =1.5V		TBD		mA	
Stand by Current			TBD		uA	6

Note4) Because current of analog circuit depends on the registers' values, refer to the recommended registers' values.

Note5) Because power consumption of VDD:I depends on the output load and system environment, user should supply enough current to sensor for stable operation. It is measured when output load is floated.

Note6) Stand by current is measured at Chip Enable = LO and MCLK = LO.

We recommend that power should be turned off, when low standby power consumption is required.

[Table 6. Absolute Maximum Ratings]



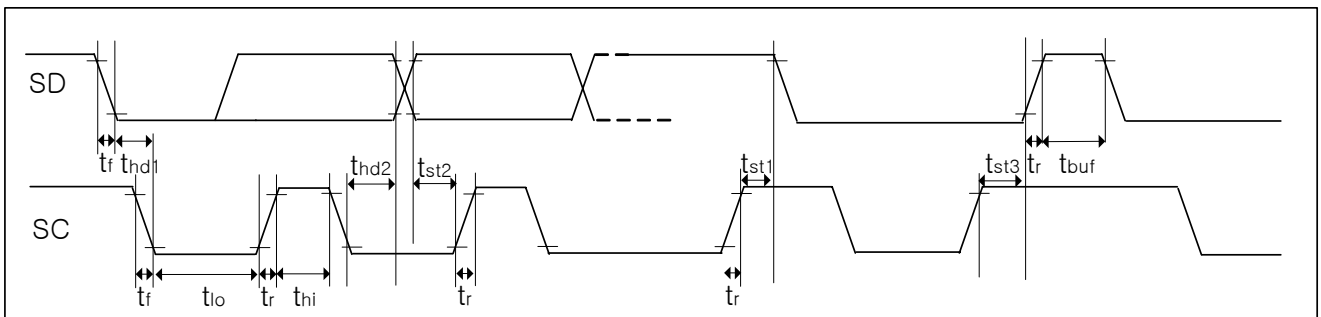
Item	Symbol	Min	Max	Note
Digital Core Power	$V_{DD:C}$	-0.3V	1.9 V	7
Analog and Pixel Power	$V_{DD:A}$ & $V_{DD:P}$	-0.3V	3.3V	7
Digital I/O Power	$V_{DD:I}$	-0.3V	3.3V	7
Input Pin Voltage	V_{IN}	-0.2V	$V_{DD:I} + 0.2V$	7
Output Pin Voltage	V_{OUT}	-0.2V	$V_{DD:I} + 0.2V$	7

Note7) Exposure to absolute maximum rating conditions for extended periods may affect reliability

4. TWO-WIRE SERIAL BUS INTERFACE

4.1. Timing Specifications

<Figure 4. AC Timing of Two Wire Serial Bus>



[Table 7. AC Characteristics of Two Wire Serial Bus]

Parameter	Symbol	Min.	Typ.	Max.	Unit
SC frequency	f_{sck}			400	KHz
SC low period	t_{lo}	1.2		-	us
SC high period	t_{hi}	0.6		-	us
SC setup time for START condition	t_{st1}	0.6		-	us
SC setup time for STOP condition	t_{st3}	0.6		-	us
SC hold time for START condition	t_{hd1}	0.6		-	us
SD setup time	t_{st2}	0.6		-	us
SD hold time	t_{hd2}	0.6		-	us
Bus free time Between a STOP and START condition	t_{buf}	0.6		-	us
Rising time of both SD and SC	t_r	-		0.3	us
Falling time of both SD and SC	t_f	-		0.3	us
Capacitive load of SC/SD	C_b	-		200	pF
Pull-up resistor on SC and SD			4.7		k Ω



4.2. Bus Operation

The two-wire serial bus interface is used to write and read the required data into registers in this sensor. Sensor can operate as a slave device only. The two-wire serial bus interface is controlled by SD (serial data) and SC (serial clock). SD is bidirectional bus.

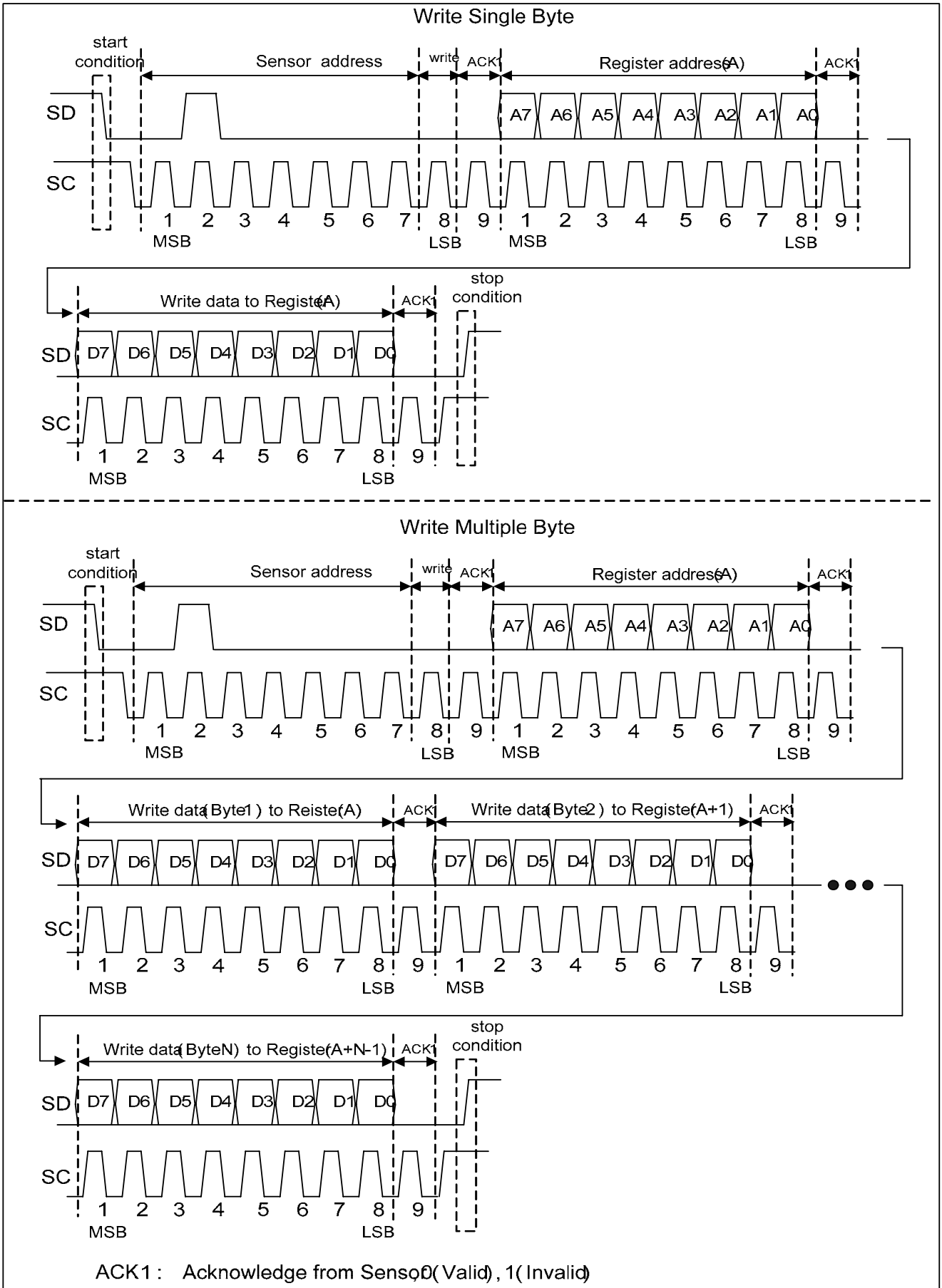
Operation has single byte programming and multiple byte programming. User doesn't need to set continuously register address on programming multiple byte because sensor increases register address automatically. This will reduce time to program registers.

Following figures show write and read operations.

Note) Before programming the two-wire serial bus interface, MCLK and RESETB should be supplied.

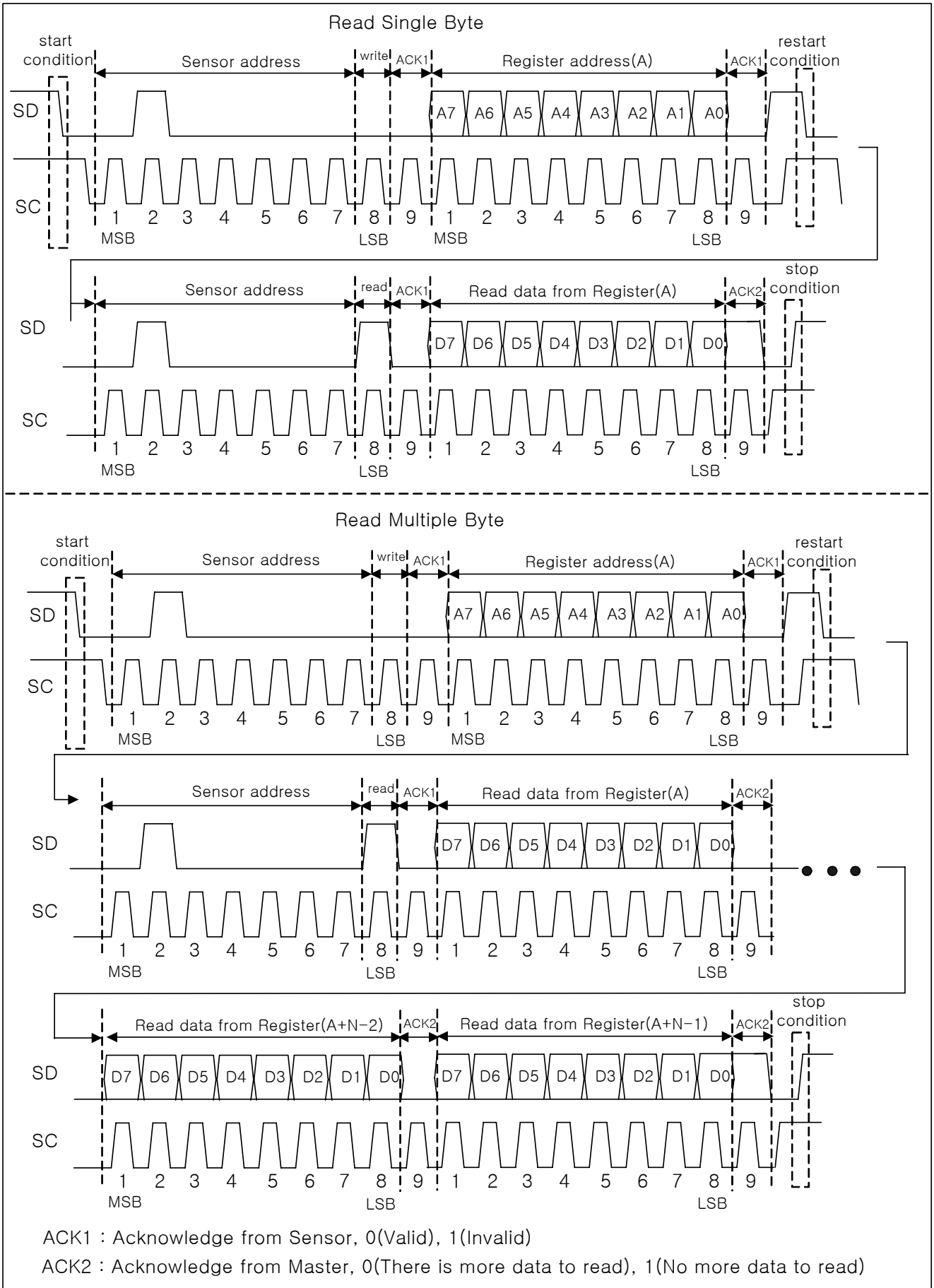


<Figure 5. Write Operation through Two Wire Serial Bus>





<Figure 6. Read Operation through Two Wire Serial Bus >



5. FUNCTION DESCRIPTION

[Table 8. Functional Description]

Function	Page Mode	Address	Description	
Power control	0	0x01	Power sleep(Software power down)	19
PLL	0	0x02, 0x08, 0x09, 0x0A	Control PLL(Phase locked loop)	10
Page mode	Common	0x03	User should change the this register before controlling functions in other page.	
Device ID	0	0x04	To find version of SENSOR, read this register.	
Image Size	0	0x10, 0x11	Sub-sampling, Preview, X/YFlip, Bad Frame Skip, Fixed Frame Rate.	16 17
Windowing	0	0x13 ~ 0x1A	Control image size by controlling windowing	12
H/VSYNC	0	0x12, 0x1B ~ 0x1F 0xA1~0xA3	Control VSYNC/HSYNC Horizontal Synchronization / Vertical Synchronization[Type1] Vertical Synchronization[Type2]	13
Black Level Calibration	0	0x20 ~ 0x2E	Calculate black level and calibrate it automatically.	1
Strobe	0	0x30 ~ 0x32	Control XENON / LED type for strobe	18
Output Data Format	1	0x10	YUV4:2:2, RGB5:6:5, RGB4:4:4, ITU656-like	6,11
Image Effect	1	0x11 ~ 0x1F, 0x23 ~ 0x2A	Brightness, Chrominance Offset/Constant, Sketch, Embossing, Solarization, Mono, Sepia etc	
Color Saturation	1	0x20 ~ 0x22	Control the gain of U/V chrominance to get vivid color reproduction.	5
Color Correction	1	0x30~0x52	Control the color correction	4
Gamma Correction	1	0x60 ~ 0x73	Control the piecewise linear lines for Gamma Correction	3
Edge Enhancement	1	0x90 ~ 0x9E	Control gain of edge enhancement	7
Noise Reduction	1	0xA0~0xBF	Control LPF for noise reduction	
Dead Pixel Concealment	1	0xC0, 0xC2	Control the dead pixel concealment	
Lens Shading Correction	2	0xA0 ~ 0xD8	Control the coefficient of lens shading correction	2
Image Scaling	2	0x10 ~ 0x21	Free Image Scaling : 1x ~ 1/64x	14
Auto Focus	2	0x30 ~ 0x4F	Control the edge data for auto focus	15
Auto Flicker Cancellation	2	0x50 ~ 0x55	To detect 100Hz / 120Hz, control the coefficient of auto flicker cancellation.	
Image Statistics	2	0x60 ~ 0x9F	Calculate the Image Statistics	
Auto Exposure	3		Control the method of auto exposure.	8
Auto White Balance	4		Control the method of auto white balance.	9

5.1. Black Level Calibration(BLC)

Black level is caused from pixel characteristics and analog channel offset. It makes poor image quality in dark condition and misleads color balance. To reduce these phenomenon, sensor automatically calibrates the black level every frame. The masked pixels in pixel array is used to calculate the black level.

5.2. Lens Shading Correction(LSC)

The circumstance area of pixel array does not have enough quantity of light due to optical characteristics of lens. It causes reduction of signal near peripheral of pixel array. The reduction of signal depends on both pixel's location and color. To compensate the problem, shading correction is done by controlling the correction gain, which depends on pixel's location and color.

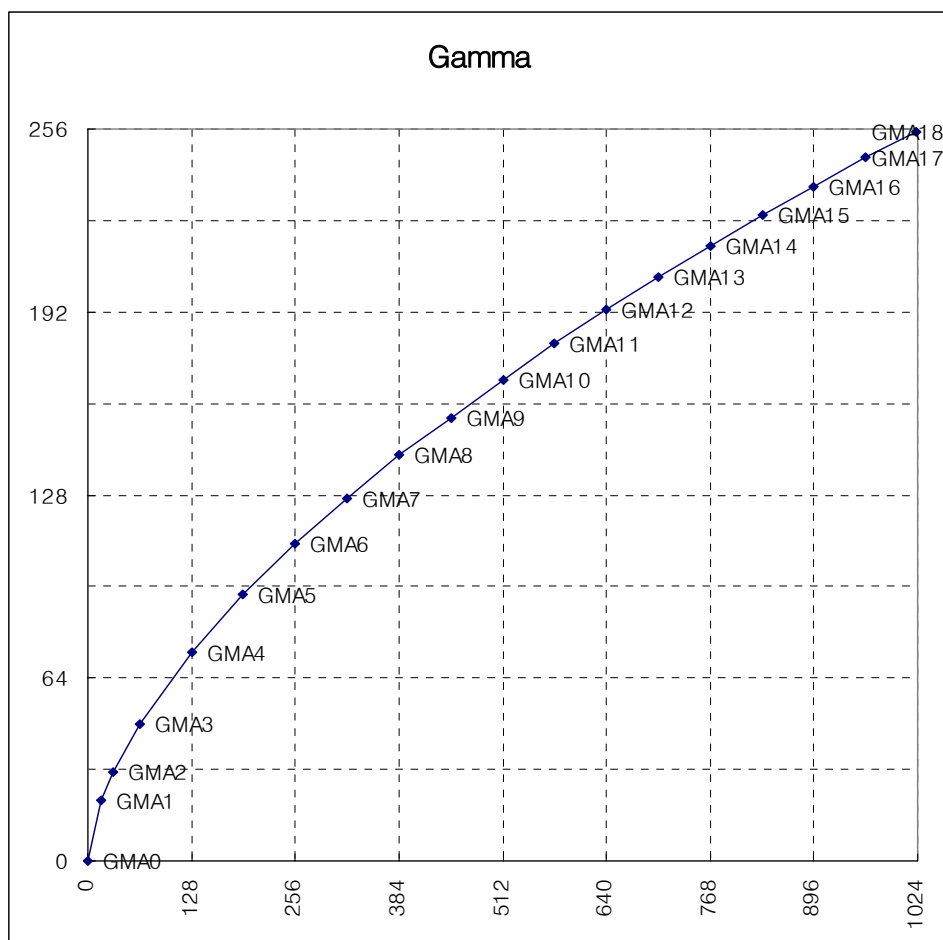
It is possible to compensate the deviation between center of lens and center of pixel array by controlling XCEN[0xA2:P1], YCEN[0xA3:P1].

5.3. Gamma Correction

Gamma correction operates on the RGB data to compensate non-linear characteristics of display device. Sensor can implement gamma correction by converting 10bit data input to 8bit data output. In following figure, piecewise linear lines are made to implement gamma curve by using 19points[GMA0 ~GMA18]. User can get various gamma curves by controlling 19points[GMA0 ~GMA18].

X-axis is 10bit-input of gamma block and Y-axis is 8bit-output of gamma block.

<Figure 7. Gamma curve>





5.4. Color Correction

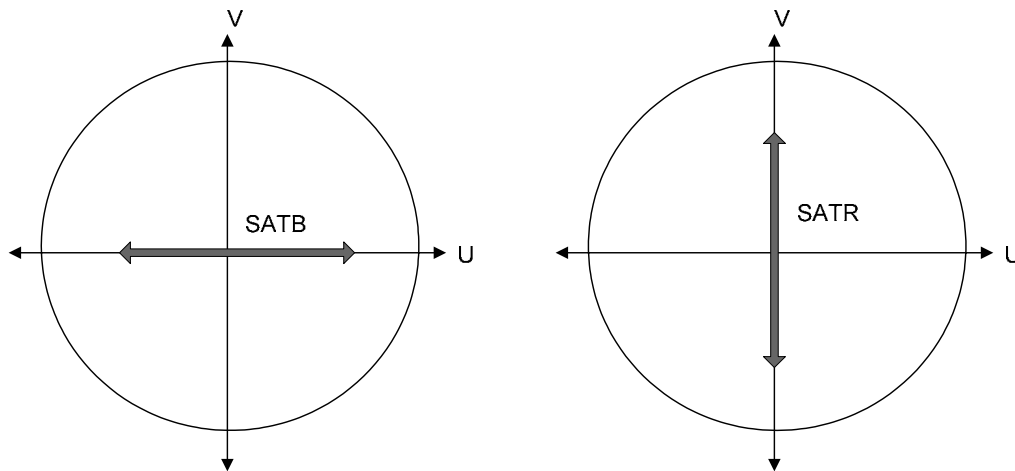
The spectral response of image sensor caused by color filter, is not the same with that of human eye. This spectral response is compensated by programming 3X3 matrix. 9-elements of matrix are controlled by CMC11[0x38:P1] ~ CMC33[0x40:P1] and CMCSIGN[0x36:P1].

$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} CMC11 & CMC12 & CMC13 \\ CMC21 & CMC22 & CMC23 \\ CMC31 & CMC32 & CMC33 \end{bmatrix} * \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

5.5. Color Saturation

User can get more vivid color reproduction by adjusting chrominance U/V. Color saturation is adjusted by controlling bit[3:0] of SATCTL[0x20:P1], SATB[0x21:P1] and SATR[0x22:P1]. Color saturation controls the gain of U/V chrominance. As AG[0x50:P3] is increased, color saturation is decreased by adjusting bit[3:2] of SATCTL [0x20:P1] automatically.

<Figure 8. Color Saturation>



5.6. Color Space Conversion

Equation of RGB to YUV color space conversion

$$Y = 0.301 * R + 0.586 * G + 0.113 * B$$

$$U = -0.168 * R - 0.332 * G + 0.5 * B + 128$$

$$V = 0.5 * R - 0.418 * G - 0.082 * B + 128$$

Equation of YUV to RGB color space conversion

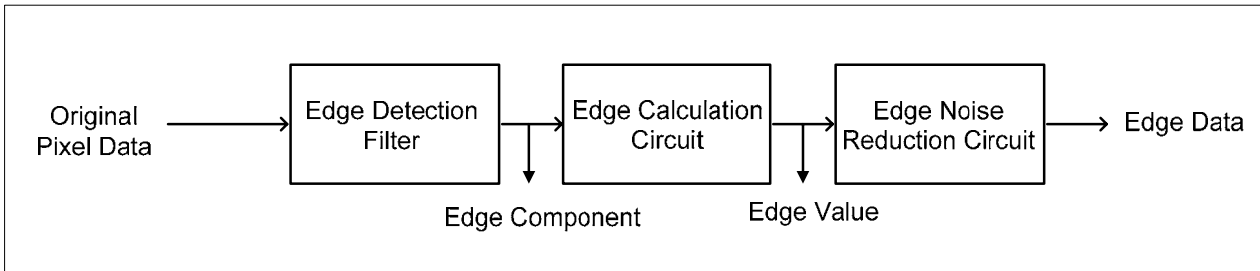
$$R = Y + 1.402 * (V - 128)$$

$$G = Y - 0.344 * (U - 128) - 0.715 * (V - 128)$$

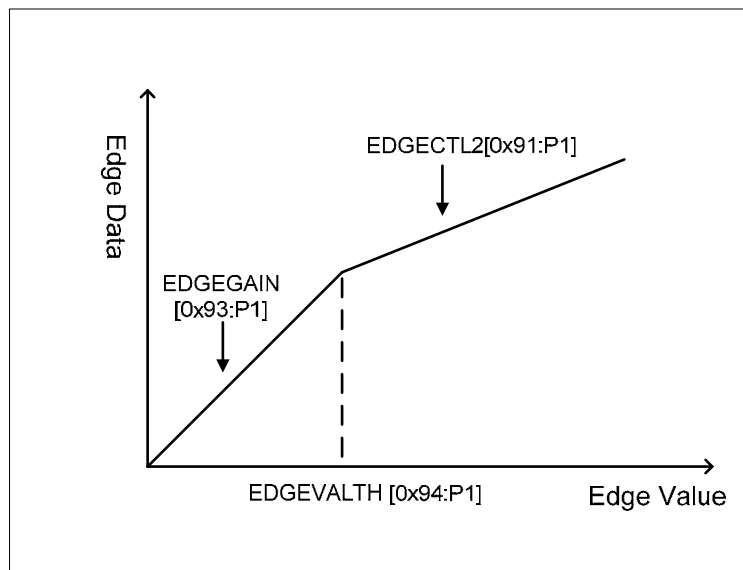
$$B = Y + 1.773 * (U - 128)$$

5.7. Edge Enhancement

<Figure 9. Edge Enhancement>



To get clear and sharp image, sensor has edge enhancement function that is composed of edge detection filter, edge calculation circuit and edge noise reduction circuit. User can control the each function by adjusting related registers[0x90 ~ 0x9E:P1].



5.8. Auto Exposure Control

AE function controls AG (automatic gain) and exposure time to maintain the proper luminance level that is determined by YLVL and image statistics. When bit[7] of AECTL1 [0x10:P3] is enabled, automatic gain and exposure time will be controlled to get a good image quality automatically. Then overall luminance on image will be entered into convergence region near to proper luminance level. If overall luminance comes out of convergence region, control of exposure time, automatic gain and digital gain will be continued until it goes inside convergence region. As overall luminance is far from convergence region, it will take longer time to enter convergence region. To overcome this problem, user can control the convergence speed by adjusting some registers. Convergence speed depends on the steps of exposure time and automatic gain.

5.9. Auto White Balance

AWB function controls RGAIN, GGAIN and BGAIN to compensate for color temperature of the light source. When bit[7] of AWBCTL1 [0x10:P4] is enabled, RGAIN and BGAIN will be controlled to get a color balanced image automatically. Then overall chrominance on image will be entered into convergence region near to ULVL[0x60:P4] and VLVL[0x61:P4]. If overall chrominance comes out of convergence region, control of RGAIN and BGAIN will be continued until it goes inside convergence region. However, when overall chrominance is far from locking region and is in color region, control of RGAIN and BGAIN will be stopped. And it is possible to define convergence region and color region by adjusting ULVL[0x60:P4], VLVL[0x61:P4], UVTH1[0x20:P4] and UVTH2[0x21:P4]

Convergence Region) $ULVL - UVTH1[7:4] \leq \text{Overall Chrominance U} \leq ULVL + UVTH1[7:4]$ and

$VLVL - UVTH1[7:4] \leq \text{Overall Chrominance V} \leq VLVL + UVTH1[7:4]$

Color Region) $\text{Overall Chrominance U} \geq ULVL + 8 * UVTH2[3:0]$ or $\text{Overall Chrominance U} \leq ULVL - 8 * UVTH2[3:0]$

$\text{Overall Chrominance V} \geq VLVL + 8 * UVTH2[3:0]$ or $\text{Overall Chrominance V} \leq VLVL - 8 * UVTH2[3:0]$

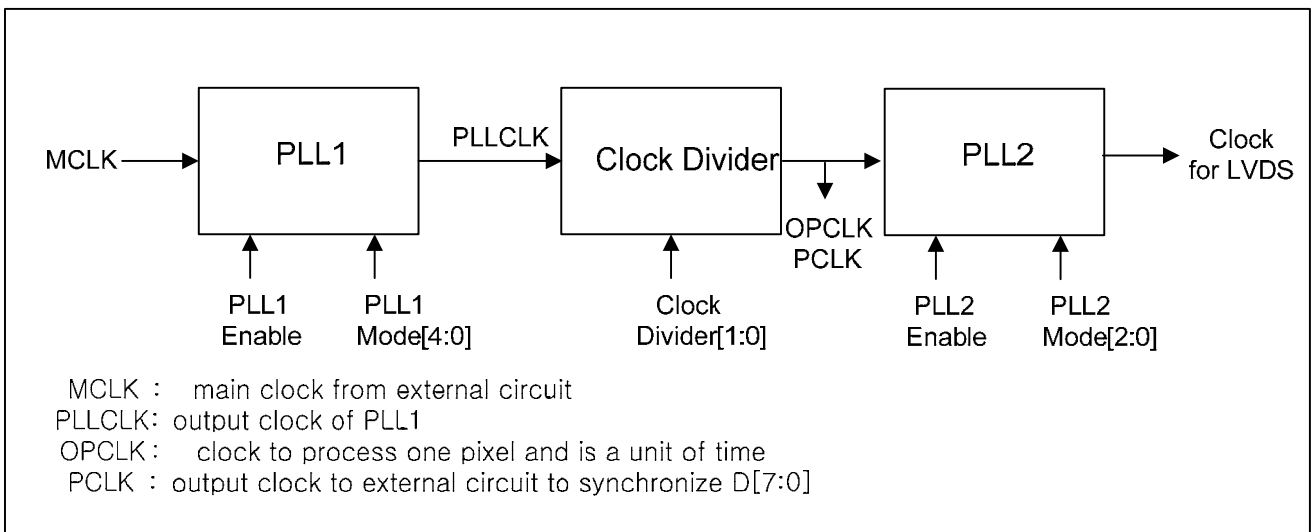
5.10. PLL(Phase Locked Loop) Control

PLL is controlled by adjusting PLLCTL1[0x02:P0], PLLCTL2[0x08:P0], PLLCTL3[0x09:P0], PLLCTL4[0x0A:P0].

Sequence of setting PLL

- 1) Enable power sleep mode (bit[0] of PWRCTL[0x01:P0])
- 2) Enable PLL and set PLL lock time and PLL Mode
- 3) Wait PLL lock time
- 4) Disable power sleep mode.

<Figure 10. Block diagram of PLL>



$$PLLCLK = [\text{Scale of PLL1 Mode}] * MCLK$$

$$OPCLK = [\text{Scale of PLL1 Mode} * \text{Scale of Clock Divider} * 1/2] * MCLK$$

$$PCLK = [\text{Scale of PLL1 Mode} * \text{Scale of Clock Divider} * \text{Scale of Sub-Sample} * \text{Scale of Preview2}] * MCLK$$

$$\text{Clock for LVDS} = [\text{Scale of PLL2 Mode}] * PCLK$$

PLL1 Mode(bit[4:0] of PLLCTL2[0x08])		1	2	3	4	5	6	7
Scale		1x	1.5x	2x	2.5x	3x	3.5x	4x
PLL1 Mode(bit[4:0] of PLLCTL2[0x08])	8	9	10	11	12	13	14	15
Scale	4.5x	5x	5.5x	6x	6.5x	7x	7.5x	8x
PLL1 Mode(bit[4:0] of PLLCTL2[0x08])	16	17	18	19	20	21	22	23
Scale	8.5x	9x	9.5x	10x	10.5x	11x	11.5x	12x
PLL1 Mode(bit[4:0] of PLLCTL2[0x08])	24	25	26	27	28	29	30	31
Scale	12.5x	13x	13.5x	14x	14.5x	15x	15.5x	16x



PLL2 Mode(bit[7:5] of PLLCTL2[0x08])	OFF	1	6	2
Scale		8x	10x	12x

Clock Divider (bit[1:0] of SYNCCTL[0x12:P0])	0	1	2	3
Scale	1	1/2	1/4	1/8

Sub-Sample(bit[5:4] of VDOCTL1[0x10])	0	1	2	3
Scale	1	1/2	1/4	1/8

Preview2 (bit[1] of VDOCTL1[0x10])	0	1
Scale	1	2

Example) MCLK:24MHz, PLL1 Enable, Scale of PLL1 Mode=2, Scale of Clock Divider=1, Scale of Sub-Sample=1. Scale of Preview2 =1,
Scale of PLL2 Mode=1,

$$OPCLK = 2 * 1/2 * 24MHz = 24MHz, \quad PCLK = 2 * 24MHz = 48MHz, \quad \text{Clock for LVDS} = 384MHz$$

Note) OPCLK should be over the 12Mhz

5.11. Video Output Data Format

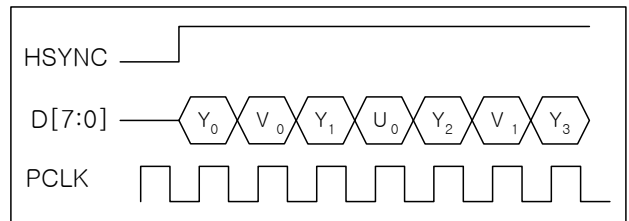
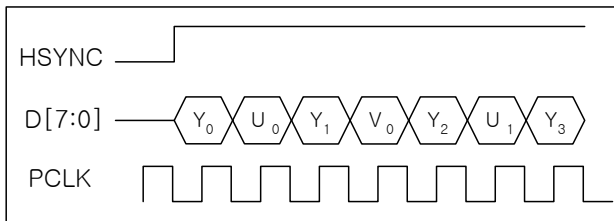
Video output data format is controlled by adjusting ISPCTL1[0x10:P1].

- YUV4:2:2

<Figure 11. Timing of YUV4:2:2>

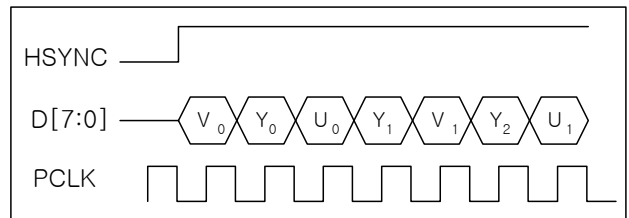
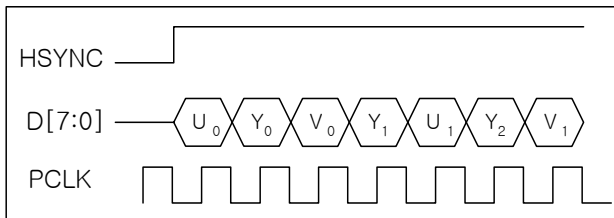
Case1) bit[1] of ISPCTL1: ON and bit[0] of ISPCTL1: ON

Case2) bit[1] of ISPCTL1: ON and bit[0] of ISPCTL1: OFF



Case3) bit[1] of ISPCTL1: OFF and bit[0] of ISPCTL1: ON

Case4) bit[1] of ISPCTL1: OFF and bit[0] of ISPCTL1: OFF

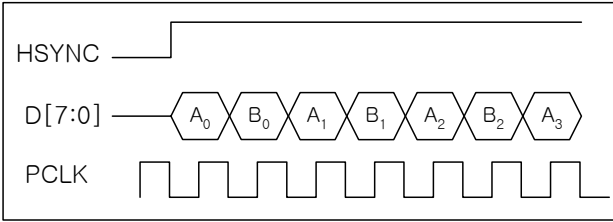




- RGB5:6:5

<Figure 12. Timing of RGB5:6:5>

Following figure shows the output timing of RGB 5:6:5 8bit



Case 1) bit[1] of ISPCTL1: ON and bit[0] of ISPCTL1: ON, Where is A = (G[7:2],B[7:6]), B = (B[5:3],R[7:3]).

Pin Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
A	G[7]	G[6]	G[5]	G[4]	G[3]	G[2]	B[7]	B[6]
B	B[5]	B[4]	B[3]	R[7]	R[6]	R[5]	R[4]	R[3]

Case 2) bit[1] of ISPCTL1: ON and bit[0] of ISPCTL1: OFF, Where is A = (G[7:2],R[7:6]), B = (R[5:3],B[7:3]).

Pin Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
A	G[7]	G[6]	G[5]	G[4]	G[3]	G[2]	R[7]	R[6]
B	R[5]	R[4]	R[3]	B[7]	B[6]	B[5]	B[4]	B[3]

Case 3) bit[1] of ISPCTL1: OFF and bit[0] of ISPCTL1: ON, Where is A = (B[7:3],G[7:5]), B = (G[4:2],R[7:3]).

Pin Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
A	B[7]	B[6]	B[5]	B[4]	B[3]	G[7]	G[6]	G[5]
B	G[4]	G[3]	G[2]	R[7]	R[6]	R[5]	R[4]	R[3]

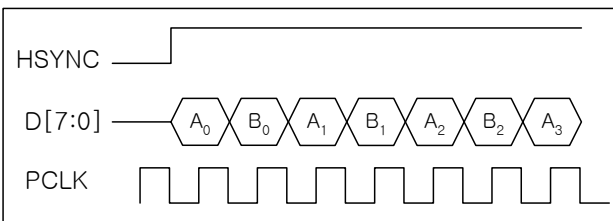
Case 4) bit[1] of ISPCTL1: OFF and bit[0] of ISPCTL1: OFF, Where is A = (R[7:3],G[7:5]), B = (G[4:2],B[7:3]).

Pin Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
A	R[7]	R[6]	R[5]	R[4]	R[3]	G[7]	G[6]	G[5]
B	G[4]	G[3]	G[2]	B[7]	B[6]	B[5]	B[4]	B[3]

- RGB4:4:4

<Figure 13. Timing of RGB4:4:4>

Following figure shows the output timing of RGB 4:4:4 8bit.



Case 1) bit[1] of ISPCTL1: ON and bit[0] of ISPCTL1: ON

Pin Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
A	0	0	0	0	G[7]	G[6]	G[5]	G[4]
B	B[7]	B[6]	B[5]	B[4]	R[7]	R[6]	R[5]	R[4]

Case 2) bit[1] of ISPCTL1: ON and bit[0] of ISPCTL1: OFF



Pin Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
A	0	0	0	0	G[7]	G[6]	G[5]	G[4]
B	R[7]	R[6]	R[5]	R[4]	B[7]	B[6]	B[5]	B[4]

Case 3) bit[1] of ISPCTL1: OFF and bit[0] of ISPCTL1: ON

Pin Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
A	0	0	0	0	B[7]	B[6]	B[5]	B[4]
B	G[7]	G[6]	G[5]	G[4]	R[7]	R[6]	R[5]	R[4]

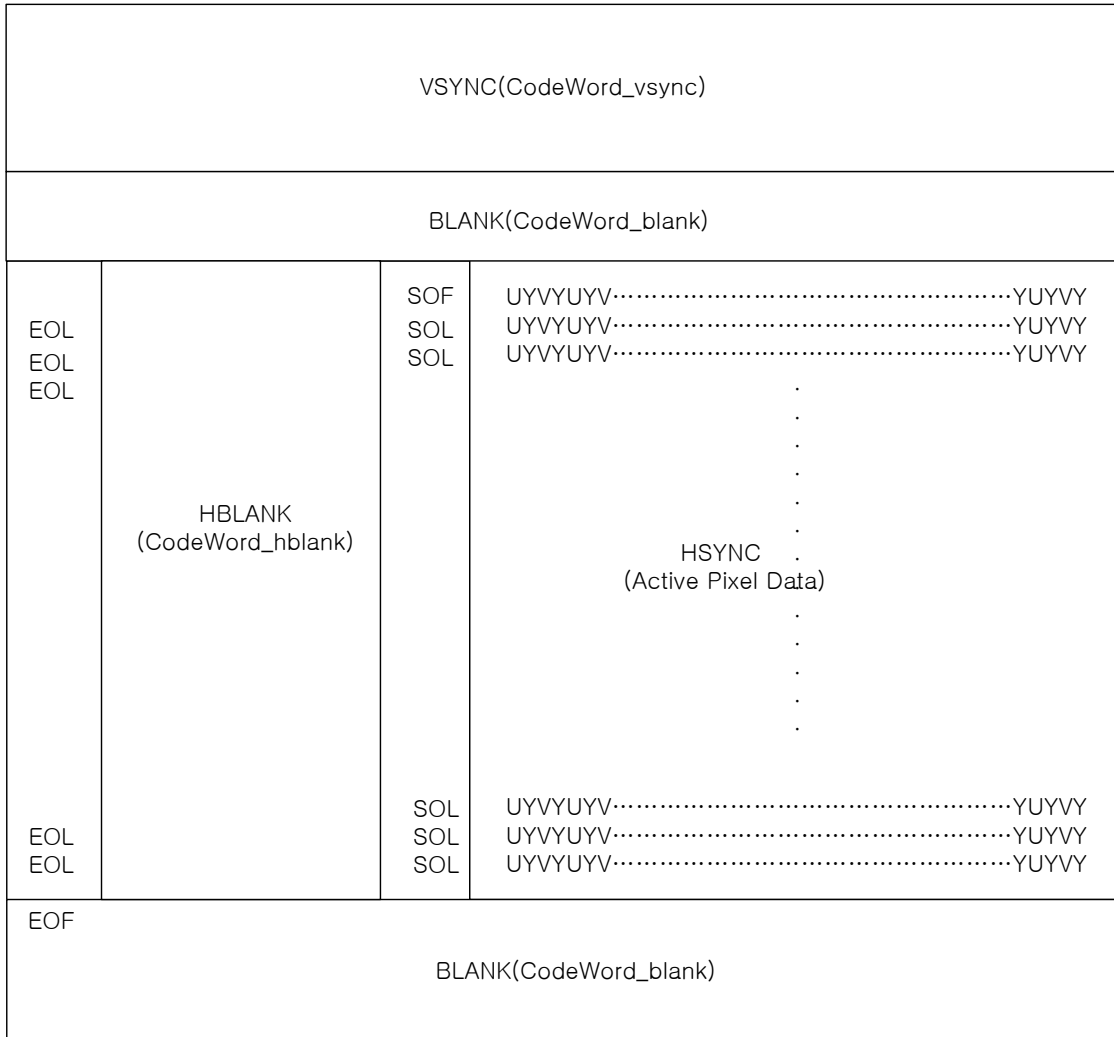
Case 4) bit[1] of ISPCTL1: OFF and bit[0] of ISPCTL1: OFF

Pin Name	D[7]	D[6]	D[5]	D[4]	D[3]	D[2]	D[1]	D[0]
A	0	0	0	0	R[7]	R[6]	R[5]	R[4]
B	G[7]	G[6]	G[5]	G[4]	B[7]	B[6]	B[5]	B[4]

- ITU656-like

To use this mode, user should set bit[2] of ISPCTL1[0x10:P1] to ON.

<Figure 14. Frame structure of ITU656-like mode>



VSYNC(CodeWord_vsync) = 0x8010 for bit[4] of ISPCTL5[0x14:P1] = OFF

0x0000 for bit[4] of ISPCTL5[0x14:P1] = ON

HBLANK(CodeWord_hblank) = 0x8010 for bit[4] of ISPCTL5[0x14:P1] = OFF

0x0000 for bit[4] of ISPCTL5[0x14:P1] = ON

BLANK(CodeWord_blank) = 0x8010 for bit[4] of ISPCTL5[0x14:P1] = OFF

0x0000 for bit[4] of ISPCTL5[0x14:P1] = ON

SOF = 0xFF000010 for bit[0] of ISPCTL5[0x14:P1] = OFF

EOF = 0xFF000001 for bit[0] of ISPCTL5[0x14:P1] = OFF

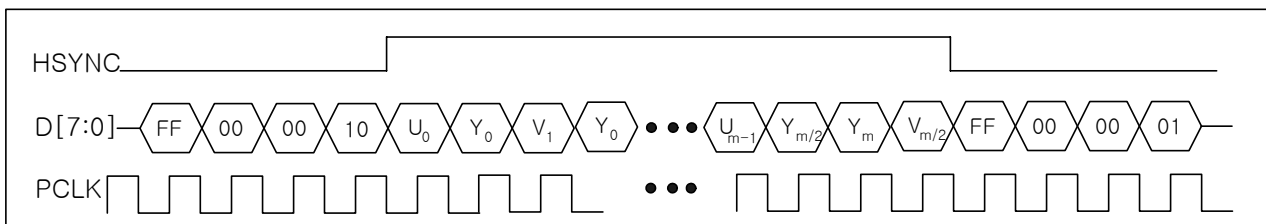
0xFF000020 for bit[0] of ISPCTL5[0x14:P1] = ON

0xFF000002 for bit[0] of ISPCTL5[0x14:P1] = ON

SOL = 0xFF000010

EOL = 0xFF000001

Following figure shows the SOL, EOL and image data in one line.



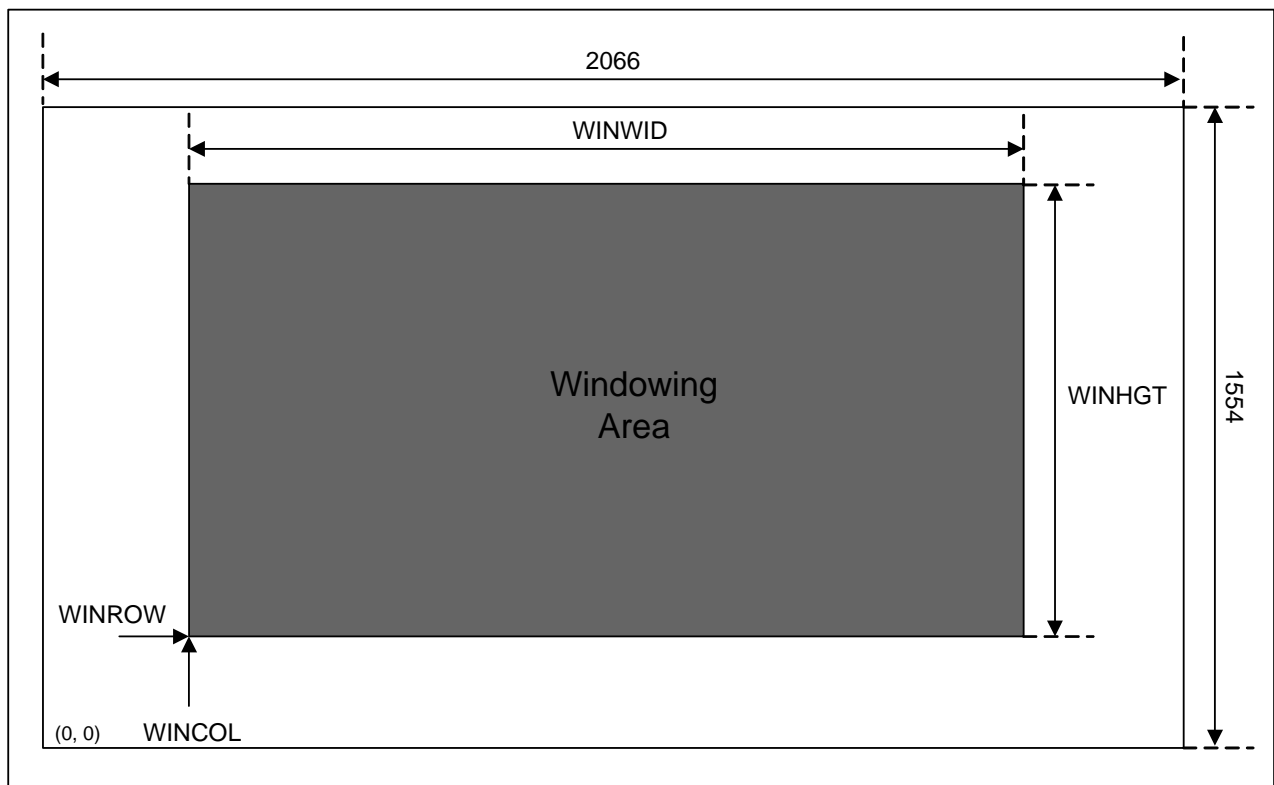
5.12. Windowing

Sensor has a rectangular pixel array 2066 X 1554. The array can be windowed by controlling WINROW[0x13, 0x14:P0], WINCOL[0x15,0x16:P0], WINHGT[0x17, 0x18:P0] and WINWID[0x19, 0x1A:P0] when bit[7] of VDOCTL2[0x11:P0] is enabled.

Following Table shows the recommended setting for each image size.

Image Type	Output Image Size	VDOCTL1 [0x10:P0]	Preview1	Preview2	WINROW [0x13, 14:P0]	WINCOL [0x15, 16:P0]	WINHGT [0x17, 18:P0]	WINWID [0x19, 1A:P0]
QXGA	2048 X 1536	0x00	OFF	OFF	0x00, 0x09	0x00, 0x09	0x06, 0x00	0x08, 0x00
XGA	1024 X 768	0x10	OFF	OFF	0x00, 0x09	0x00, 0x09	0x06, 0x00	0x08, 0x00
	1024 X 768	0x11	ON	OFF	0x00, 0x04	0x00, 0x09	0x06, 0x00	0x08, 0x00
	1024 X 768	0x13	ON	ON	0x00, 0x04	0x00, 0x04	0x06, 0x00	0x08, 0x00
	512 X 384	0x20	OFF	OFF	0x00, 0x09	0x00, 0x09	0x06, 0x00	0x08, 0x00
	512 X 384	0x21	ON	OFF	0x00, 0x04	0x00, 0x09	0x06, 0x00	0x08, 0x00
	512 X 384	0x23	ON	ON	0x00, 0x04	0x00, 0x04	0x06, 0x00	0x08, 0x00

<Figure 15. Windowing>



5.13. Frame Structure

Frame Structure is frame timing and it is controlled by HBLANK[0x1B,0x1C:P0] and VSYNC[0x1D, 0x1E:P0] and VSCLIP[0x1F:P0].

When exposure time is less than the data line time, figure 16 and figure 17 is valid.

If the exposure time is over the data line time, the difference will be inserted between Image Data and Valid VSYNC.

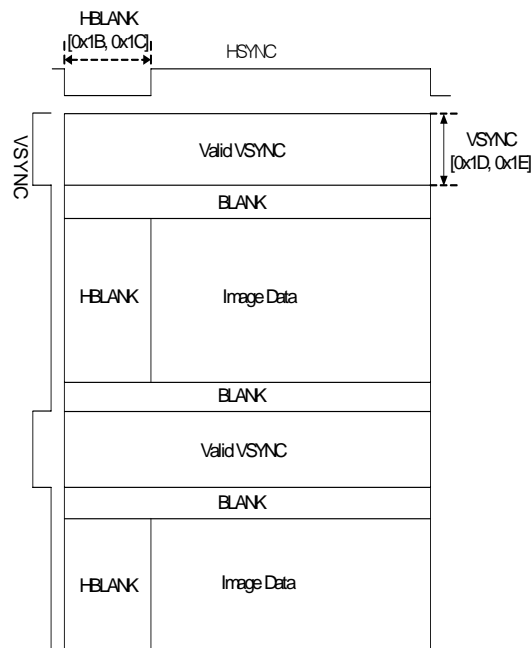
Where data line time is $(2080 + \text{HBLANK}) \times 1536 \times \text{OPCLK's period}$ for full size,

$(2080 + \text{HBLANK}) \times 784 \times \text{OPCLK's period}$ for preview1,

$(1044 + \text{HBLANK}) \times 784 \times \text{OPCLK's period}$ for preview2

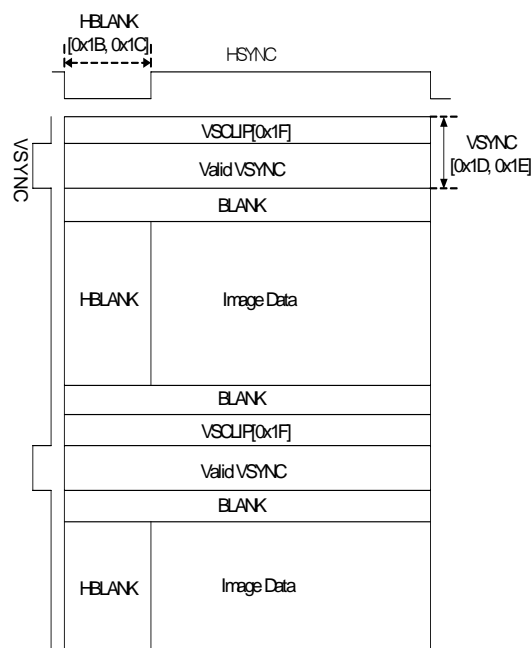
<Figure 16. Frame Structure when VSYNC Clip is disabled>

Case1) bit[3] of SYNCTL [0x12:P0] is OFF



<Figure 17. Frame Structure when VSYNC Clip is enabled>

Case2) bit[3] of SYNCTL [0x12:P0] is ON



5.14. Image Scaling

Sensor supports image scaling when the output scaling size is smaller than the original image size. Image scaling is done using the YUV data. Output scaling size is controlled in x or y direction independently with ZOUTWID[0x12, 0x13:P2] and ZOUTHGT[0x14, 0x15:P2]. And user should also set the ZFIFODLY[0x22:P2], ZVERSTEP[0x1E, 0x1F:P2] and ZHORSTEP[0x20, 0x21:P2].

$$\text{ZHORSTEP [Horizontal step]} = (\text{Image Width} / \text{ZOUTWID}) * 2048$$

$$\text{ZVERSTEP [Vertical step]} = (\text{Image Height} / \text{ZOUTHGT}) * 2048$$

$$\text{ZFIFODLY} = (\text{Image Width} - \text{ZOUTWID}) * (\text{ZOUTWID} / \text{Image Width}) / 2 + 5$$

where Image Height = WINHGT[0x17, 0x18:P0] for full size
 = WINHGT [0x17, 0x18:P0] / 2 for preivew1 or preview2

Image Width = WINWID[0x19, 0x1A:P0] for full size or preview1
 = WINWID [0x19, 0x1A:P0] / 2 for preview2

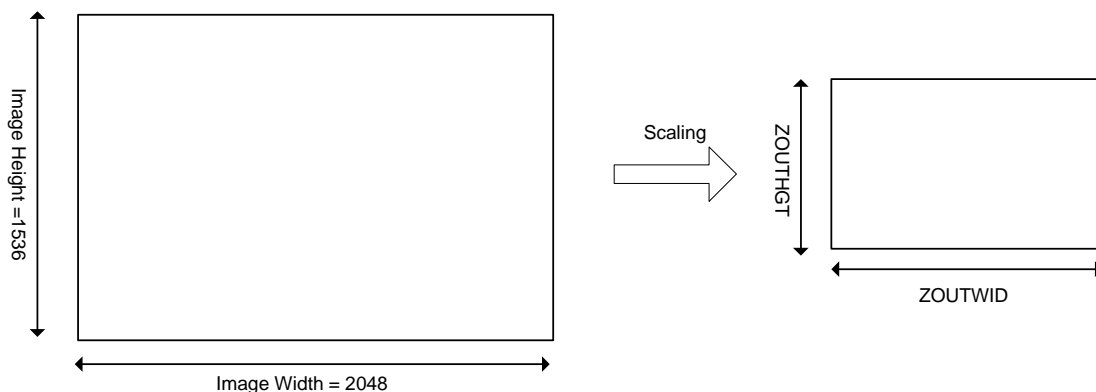
$$\text{Horizontal scaling factor} = (\text{ZOUTWID} / \text{Image Width})$$

$$\text{Vertical scaling factor} = (\text{ZOUTHGT} / \text{Image Height})$$

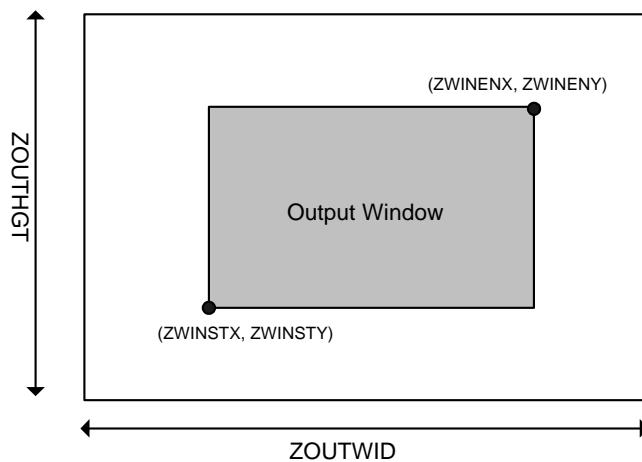
$$\text{Image scaling factor} = \text{Horizontal scaling factor} * \text{Vertical scaling factor}$$

Programmable scaling factor is 1x ~ 1/64x. Following figure shows how to scale the data from the sensor.

<Figure 18. Image Scaling>



<Figure 19. Windowing after Image Scaling>



The window size can be programmed with bit[1] of ZOOMCTL[0x10:P2], ZWINSTX[0x16, 0x17:P2], ZWINSTY[0x18, 0x19:P2],

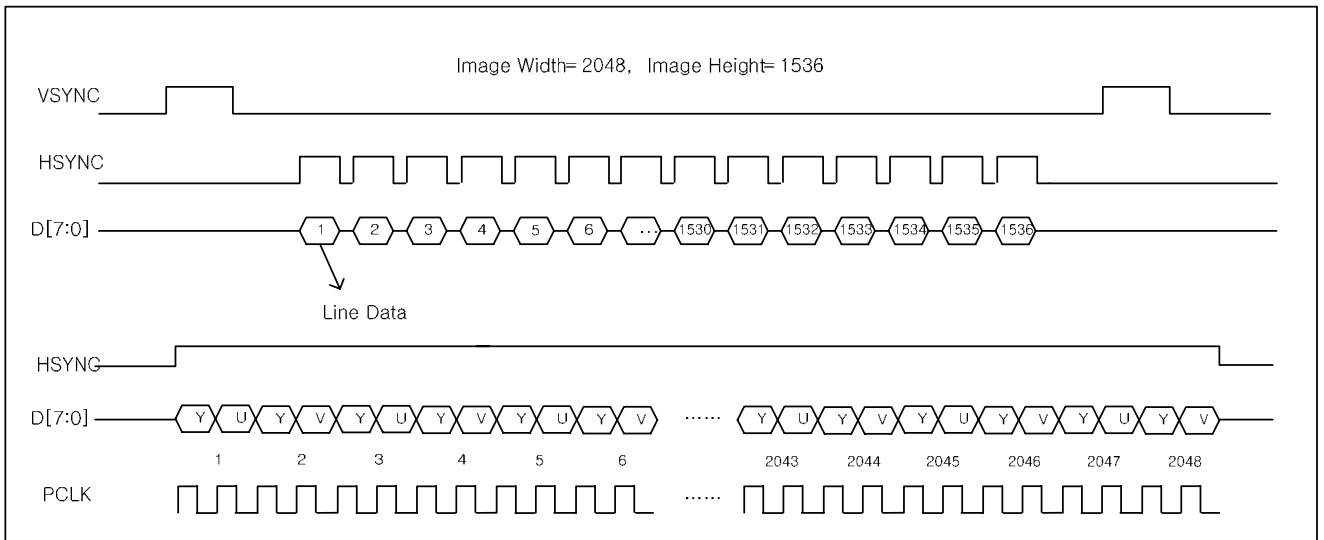
ZWINENX[0x1A, 0x1B:P2] and ZWINENY [0x1C, 0x1D:P2].

Timing of Image Scaling

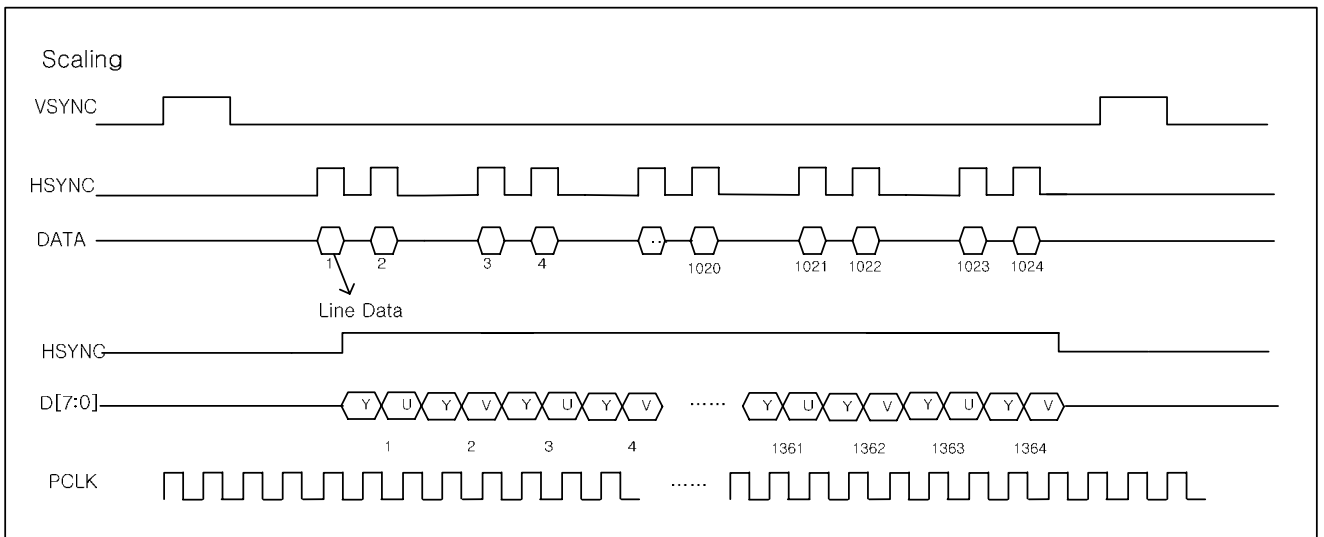
In image scaling, the width and period of HSYNC are changed but the period of frame is not changed.

Following figures show the difference of the timing diagram between normal image and scaling image.

<Figure 20. Frame before Image Scaling>



<Figure 21. Frame after Image Scaling>



5.15. Edge Data for Auto Focus

NOON300pc51 has two kinds of AF Type.

AF Type0 has 2 edge detection region to get AF data and 3 kinds of edge data in edge detection region. AF Type1 has 5 edge detection region to get AF data. AF type0 is selected by disabling bit[1] of AFCTL2[0x31:P2] and 2 regions controlled by AFR1XST [0x33:P2], AFR1YST [0x34:P2], AFR1XEN [0x35:P2], AFR1YEN [0x36:P2], AFR2XST [0x37:P2], AFR2YST [0x38:P2], AFR2XEN [0x39:P2], and AFR2YEN [0x3A:P2]. Following registers indicate edge value in each region.

AFVAL1R1[0x3E, 0x3F:P2] : Edge data of region1 when AF filter1 is used for AF type0,

AFVAL2R1[0x40, 0x41:P2] : Edge data of region1 when AF filter2 is used for AF type0,

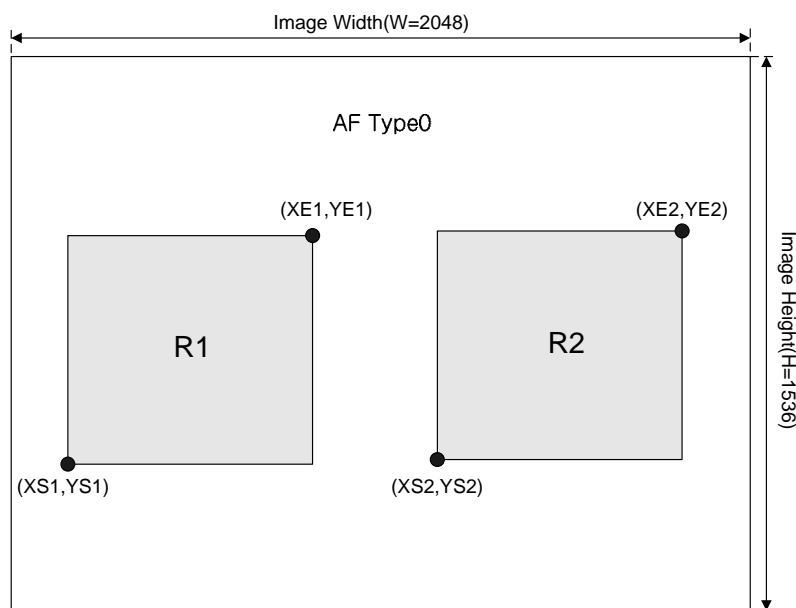
AFVAL3R1[0x46, 0x47:P2] : Edge data of region1 when AF filter3 is used for AF type0,

AFVAL1R2[0x42, 0x43:P2] : Edge data of region2 when AF filter1 is used for AF type1,

AFVAL2R2[0x44, 0x45:P2] : Edge data of region2 when AF filter2 is used for AF type1,

AFVAL3R2[0x48, 0x49:P2] : Edge data of region2 when AF filter3 is used for AF type1

<Figure 22. Auto Focus Region : Type0>



Region1 : $XS1= AFR1XST * 8$, $YS1= AFR1YST * 8$, $XE1= AFR1XEN * 8$, $YE1= AFR1YEN * 8$,

Region2 : $XS2= AFR2XST * 8$, $YS2= AFR2YST * 8$, $XE2= AFR2XEN * 8$, $YE2= AFR2YEN * 8$,

AF type1 is selected by enabling bit[1] of AFCTL2[0x31:P2] and 5 regions controlled by AFCOL1[0x37:P2], AFCOL2[0x38:P2], AFCOL3[0x39:P2], AFROW1[0x33:P2], AFROW2[0x34:P2], and AFROW3[0x35:P2].

Following registers indicate edge value in each region.

AFEDGE1[0x3E, 0x3F:P2] : Edge data of region1 for AF type1,

AFEDGE2[0x40, 0x41:P2] : Edge data of region2 for AF type1

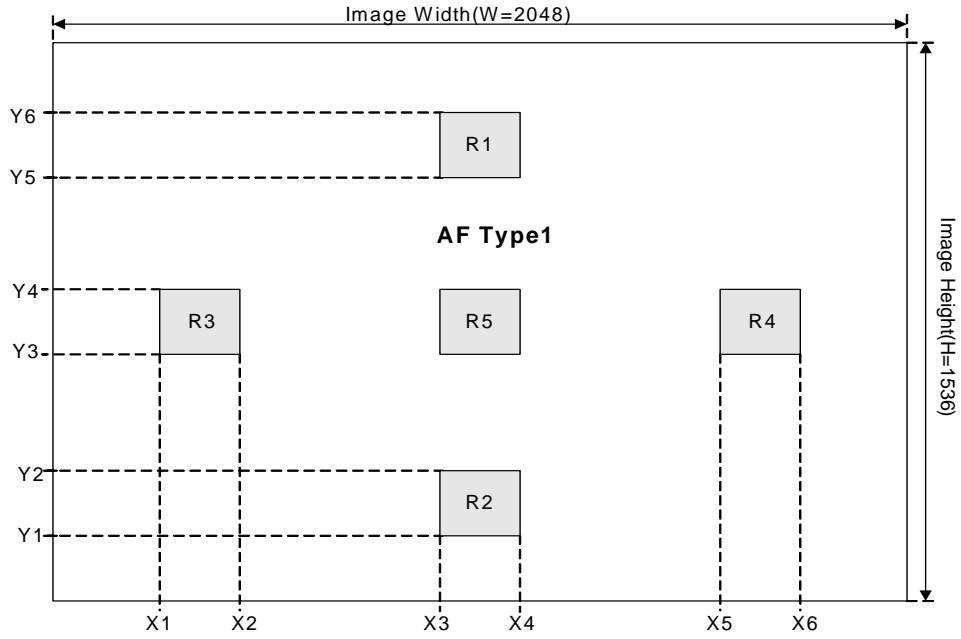
AFEDGE4[0x42, 0x43:P2] : Edge data of region3 for AF type1

AFEDGE5[0x44, 0x45:P2] : Edge data of region4 for AF type1

AFEDGE3[0x46, 0x47:P2] : Edge data of region5 for AF type1



<Figure 23. Auto Focus Region : Type1>



$$\begin{aligned}
 X1 &= W/2 - AFCOL3*4, & X2 &= W/2 - AFCOL2*4, & X3 &= W/2 - AFCOL1*4 \\
 X4 &= W/2 + AFCOL1*4, & X5 &= W/2 + AFCOL2*4, & X6 &= W/2 + AFCOL3*4 \\
 Y1 &= H/2 - AFROW3*4, & Y2 &= H/2 - AFROW2*4, & Y3 &= H/2 - AFROW1*4 \\
 Y4 &= H/2 + AFROW1*4, & Y5 &= H/2 + AFROW2*4, & Y6 &= H/2 + AFROW3*4
 \end{aligned}$$



5.16. Timing Description

Sensor supports QXGA(2048 X 1200), XGA(800 X 600), 512 X 384. Following table shows the register value for each image size.

Image Type	Output Image Size	VDOCTL1[0x10:P0]	Preview1	Preview2	Maximum Frame Rate
QXGA	2048 X 1536	0x00	OFF	OFF	15fps
XGA	1024 X 768	0x10	OFF	OFF	15fps
	1024 X 768	0x11	ON	OFF	30fps
	1024 X 768	0x13	ON	ON	50fps
	512 X 384	0x20	OFF	OFF	15fps
	512 X 384	0x21	ON	OFF	30fps
	512 X 384	0x23	ON	ON	50fps

Timing parameters

T_o : period of OPCLK that is internal clock to process one pixel. It is a unit of time in this device.

$$OPCLK = [Scale\ of\ PLL\ Mode * Scale\ of\ Clock\ Divider * 1/2] * MCLK$$

T_p : period of PCLK that is output clock to external circuit for synchronizing D[7:0].

To catch YUV data, use the PCLK because YUV data is changed by period of PCLK

$$PCLK = [Scale\ of\ PLL\ Mode * Scale\ of\ Clock\ Divider * Scale\ of\ Sub-Sample] * Scale\ of\ preview2 * MCLK$$

$$PLLCLK = [Scale\ of\ PLL1\ Mode] * MCLK$$

$$OPCLK = [Scale\ of\ PLL1\ Mode * Scale\ of\ Clock\ Divider * 1/2] * MCLK$$

$$PCLK = [Scale\ of\ PLL1\ Mode * Scale\ of\ Clock\ Divider * Scale\ of\ Sub-Sample * Scale\ of\ Preview2] * MCLK$$

$$Clock\ for\ LVDS = [Scale\ of\ PLL2\ Mode] * PCLK$$

PLL1 Mode(bit[4:0] of PLLCTL2[0x08])		1	2	3	4	5	6	7
Scale		1x	1.5x	2x	2.5x	3x	3.5x	4x
PLL1 Mode(bit[4:0] of PLLCTL2[0x08])	8	9	10	11	12	13	14	15
Scale	4.5x	5x	5.5x	6x	6.5x	7x	7.5x	8x
PLL1 Mode(bit[4:0] of PLLCTL2[0x08])	16	17	18	19	20	21	22	23
Scale	8.5x	9x	9.5x	10x	10.5x	11x	11.5x	12x
PLL1 Mode(bit[4:0] of PLLCTL2[0x08])	24	25	26	27	28	29	30	31
Scale	12.5x	13x	13.5x	14x	14.5x	15x	15.5x	16x

PLL2 Mode(bit[7:5] of PLLCTL2[0x08])	OFF	1	6	2
Scale		8x	10x	12x

Clock Divider (bit[1:0] of SYNCCTL[0x12:P0])	0	1	2	3
Scale	1	1/2	1/4	1/8



Sub-Sample(bit[5:4] of VDOCTL1[0x10])	0	1	2	3
Scale	1	1/2	1/4	1/8

Preview2 (bit[1] of VDOCTL1[0x10])	0	1
Scale	1	2

Example) MCLK:24Mhz, PLL1 Enable, Scale of PLL1 Mode=2, Scale of Clock Divider=1, Scale of Sub-Sample=1. Scale of Preview2 =1, Scale of PLL2 Mode=1,

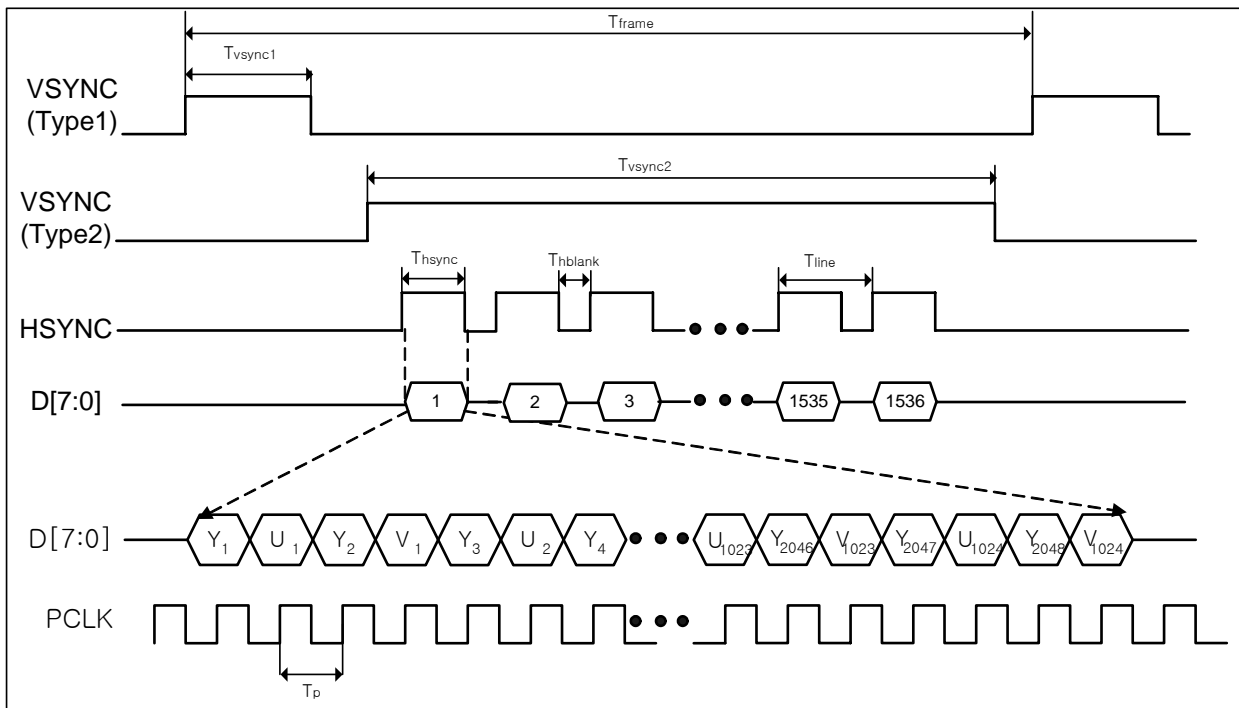
$OPCLK = 2 * 1/2 * 24MHz = 24MHz$, $PCLK = 2 * 24MHz = 48MHz$, Clock for LVDS = 384Mhz

Note)Type of VSYNC is selected by bit[2] of VDOCTL1[0x10:P0] in following figures.

VSYNC of type1 is controlled by VSYNC[0x1D, 1E:P0] registers.

VSYNC of type2 is controlled by VSCTL1[0xA1:P0], VSCTL2[0xA2:P0] and VSCTL3[0xA3:P0],

<Figure 24. Frame Timing of QXGA(2048 X 1536)>



$T_p = 1/2 * T_o$, $T_{hsync} = 2048 * T_o$, $T_{hblank} = (HBLANK + 32) * T_o$, $T_{line} = (2080 + HBLANK) * T_o$, $T_{vsync1} = VSYNC * (2080 + HBLANK) * T_o$ for type1,

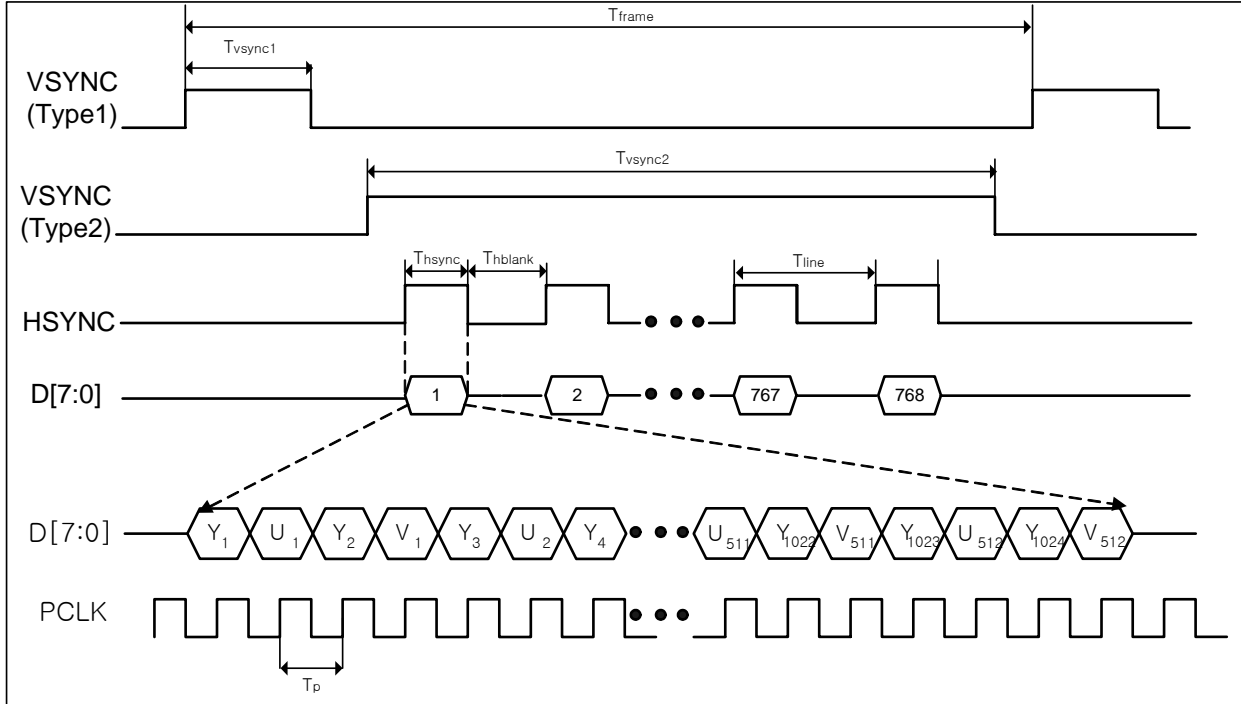
$T_{vsync2} = ((VSCTL1[3:0] * 256 + VSCTL3[7:0]) - (VSCTL1[7:4] * 256 + VSCTL2[7:0])) * (2080 + HBLANK) * T_o$ for type2,

$T_{frame} = (1564 + VSYNC) * (2080 + HBLANK) * T_o$, for $EXPINT[0x44:45,46:P3] \leq 1564 * (2080 + HBLANK) * T_o$

= $EXPINT + VSYNC * (2080 + HBLANK) * T_o$, elsewhere

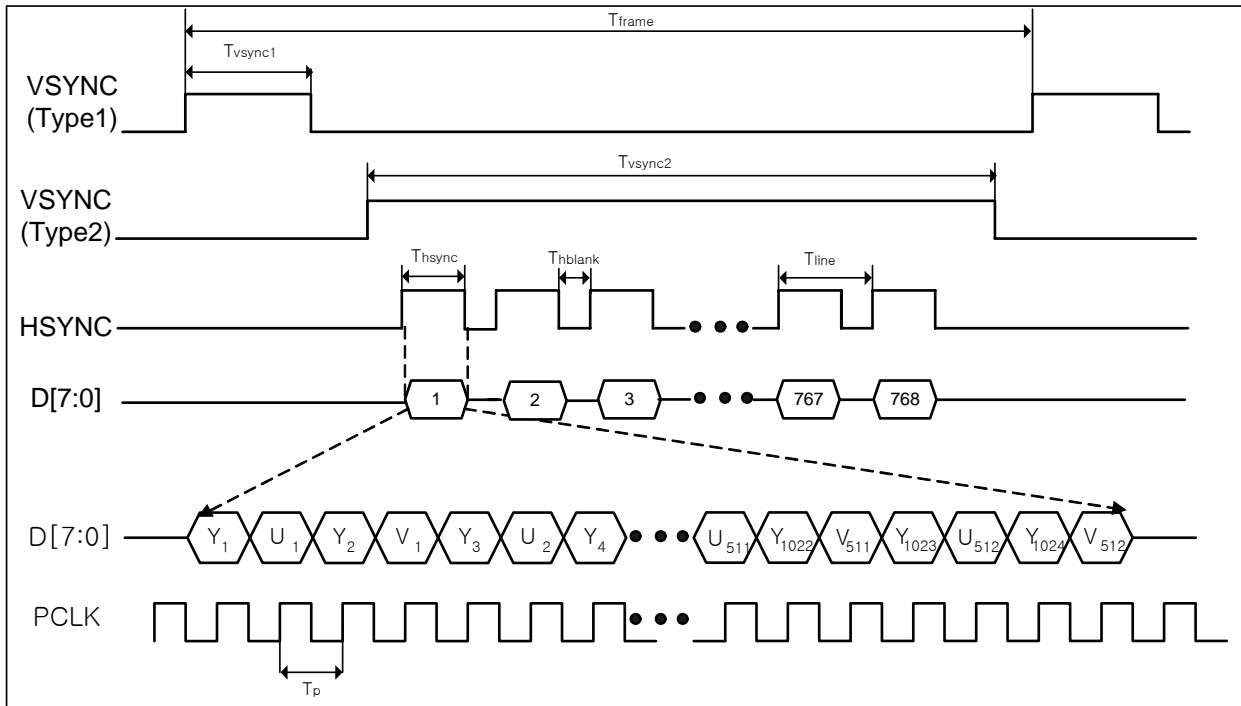


<Figure 25. Frame Timing of XGA(1024 X 768) when VDOCTL1[0x10:P0] is 0x10 >



$T_p = T_o$, $T_{hsync} = 2048 * T_o$, $T_{hblank} = (2 * HBLANK + 2112) * T_o$, $T_{line} = 2 * (2080 + HBLANK) * T_o$, $T_{vsync1} = VSYNC * (2080 + HBLANK) * T_o$ for type1,
 $T_{vsync2} = ((VSC1[3:0] * 256 + VSC3[7:0]) - (VSC1[7:4] * 256 + VSC2[7:0])) * (2080 + HBLANK) * T_o$ for type2,
 $T_{frame} = (1564 + VSYNC) * (2080 + HBLANK) * T_o$, for $EXPINT[0x44:45,46:P3] \leq 1564 * (2080 + HBLANK) * T_o$
 $= EXPINT + VSYNC * (2080 + HBLANK) * T_o$, elsewhere

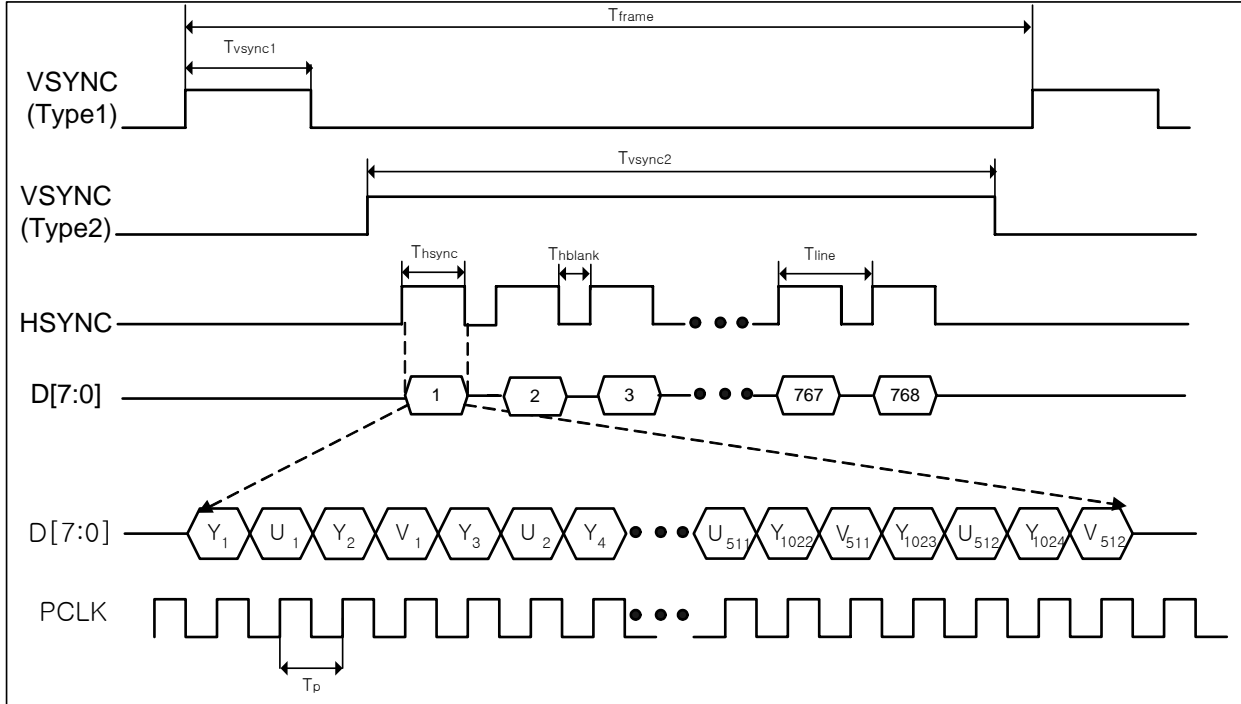
<Figure 26. Frame Timing of XGA(1024 X 768) when VDOCTL1[0x10:P0] is 0x11 >



$T_p = T_o$, $T_{hsync} = 2048 * T_o$, $T_{hblank} = (HBLANK + 32) * T_o$, $T_{line} = (2080 + HBLANK) * T_o$, $T_{vsync1} = VSYNC * (2080 + HBLANK) * T_o$ for type1,
 $T_{vsync2} = ((VSC1[3:0] * 256 + VSC3[7:0]) - (VSC1[7:4] * 256 + VSC2[7:0])) * (2080 + HBLANK) * T_o$ for type2,
 $T_{frame} = (784 + VSYNC) * (2080 + HBLANK) * T_o$, for $EXPINT[0x44:45,46:P3] \leq 784 * (2080 + HBLANK) * T_o$
 $= EXPINT + VSYNC * (2080 + HBLANK) * T_o$, elsewhere

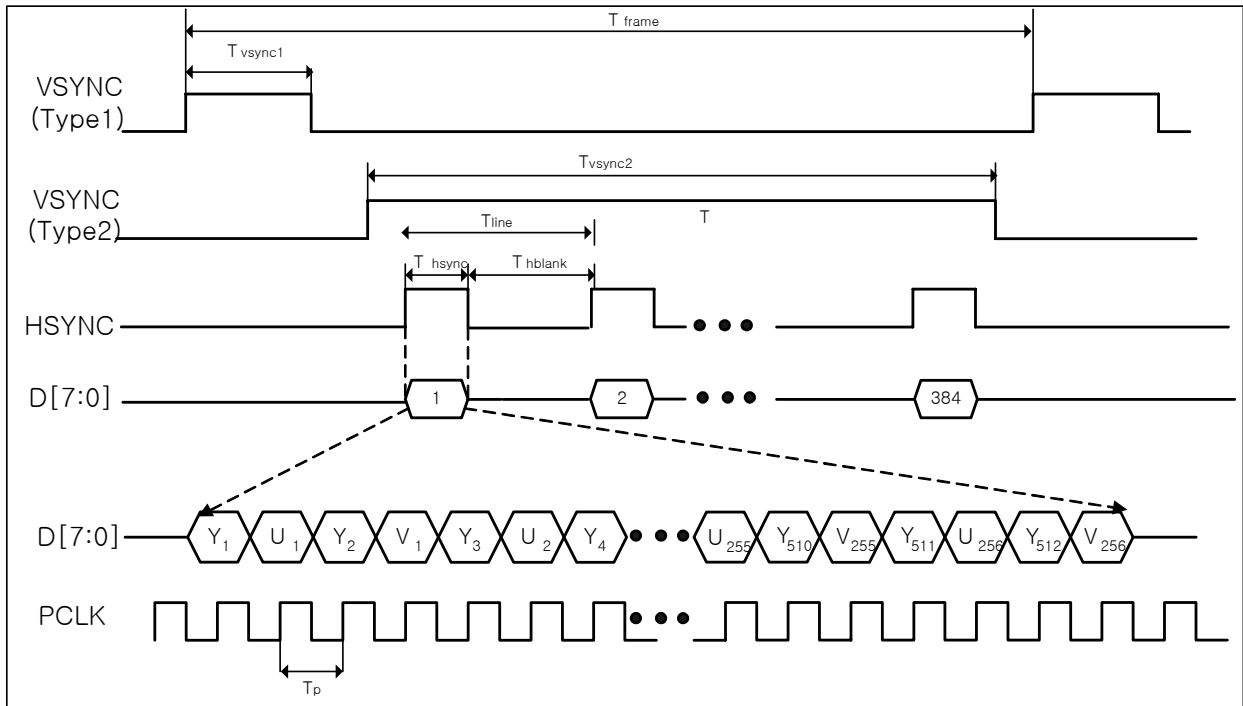


<Figure 27. Frame Timing of XGA(1024 X 768) when VDOCTL1[0x10:P0] is 0x13>



$T_p = 1/2 * T_o$, $T_{hsync} = 1024 * T_o$, $T_{blank} = (HBLANK + 20) * T_o$, $T_{line} = (1044 + HBLANK) * T_o$, $T_{vsync1} = VSYNC * (1044 + HBLANK) * T_o$ for type1,
 $T_{vsync2} = ((VSCTL1[3:0] * 256 + VSCTL3[7:0]) - (VSCTL1[7:4] * 256 + VSCTL2[7:0])) * (1044 + HBLANK) * T_o$ for type2,
 $T_{frame} = (784 + VSYNC) * (1044 + HBLANK) * T_o$, for $EXPINT[0x44:45,46:P3] \leq 784 * (1044 + HBLANK) * T_o$
 $= EXPINT + VSYNC * (1044 + HBLANK) * T_o$, elsewhere

<Figure 28. Frame Timing of 512 X 384 when VDOCTL1[0x10:P0] is 0x20>



$T_p = 2 * T_o$, $T_{hsync} = 2048 * T_o$, $T_{blank} = (4 * HBLANK + 6272) * T_o$, $T_{line} = 4 * (2080 + HBLANK) * T_o$, $T_{vsync1} = VSYNC * (2080 + HBLANK) * T_o$ for type1,
 $T_{vsync2} = ((VSCTL1[3:0] * 256 + VSCTL3[7:0]) - (VSCTL1[7:4] * 256 + VSCTL2[7:0])) * (2080 + HBLANK) * T_o$ for type2,
 $T_{frame} = (1564 + VSYNC) * (2080 + HBLANK) * T_o$, for $EXPINT[0x44:45,46:P3] \leq 1564 * (2080 + HBLANK) * T_o$
 $= EXPINT + VSYNC * (2080 + HBLANK) * T_o$, elsewhere

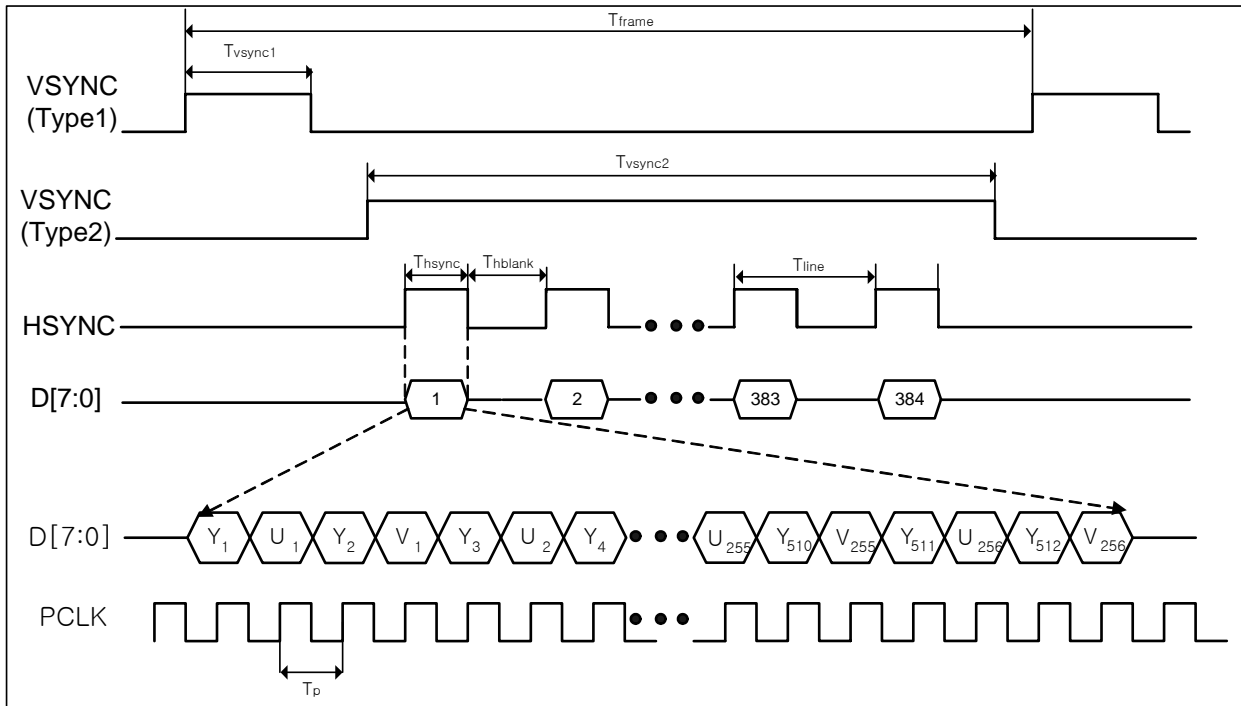


<Figure 29. Frame Timing of 512 X 384 when VDOCTL1[0x10:P0] is 0x21>



$T_p = 2 * T_o$, $T_{hsync} = 2048 * T_o$, $T_{hblank} = (2 * HBLANK + 2112) * T_o$, $T_{line} = 2 * (2080 + HBLANK) * T_o$, $T_{vsync1} = VSYNC * (2080 + HBLANK) * T_o$ for type1,
 $T_{vsync2} = ((VSC1L1[3:0] * 256 + VSC1L3[7:0]) - (VSC1L1[7:4] * 256 + VSC1L2[7:0])) * (2080 + HBLANK) * T_o$ for type2,
 $T_{frame} = (784 + VSYNC) * (2080 + HBLANK) * T_o$, for $EXPINT[0x44:45,46:P3] \leq 784 * (2080 + HBLANK) * T_o$
 $= EXPINT + VSYNC * (2080 + HBLANK) * T_o$, elsewhere

<Figure 30. Frame Timing of 512 X 384 when VDOCTL1[0x10:P0] is 0x23>



$T_p = T_o$, $T_{hsync} = 1024 * T_o$, $T_{hblank} = (2 * HBLANK + 1064) * T_o$, $T_{line} = 2 * (1044 + HBLANK) * T_o$, $T_{vsync1} = VSYNC * (1044 + HBLANK) * T_o$ for type1,
 $T_{vsync2} = ((VSC1L1[3:0] * 256 + VSC1L3[7:0]) - (VSC1L1[7:4] * 256 + VSC1L2[7:0])) * (1044 + HBLANK) * T_o$ for type2,
 $T_{frame} = (784 + VSYNC) * (1044 + HBLANK) * T_o$, for $EXPINT[0x44:45,46:P3] \leq 784 * (1044 + HBLANK) * T_o$
 $= EXPINT + VSYNC * (1044 + HBLANK) * T_o$, elsewhere

5.17. Fixed Frame Rate Timing

There are two kind of frame rate. One is fixed frame rate and other is variable frame rate.

Fixed frame rate depends on the EXPMAX and EXPFIX. It has constant frame rate regardless of changing exposure time, but maximum frame rate is slower than that of variable frame rate. Variable frame rate is faster than fixed frame rate, but the interval of frames is variable when exposure time is changed. Following table shows the frame time as various condition of EXPMAX

Note) User should consider EXPMAX, HBLANK and Frame time for auto flicker cancellation (50Hz/60Hz)

1) EXPMAX should be multiple of 1/100sec and 1/120sec for auto flicker cancellation.

Therefore 50msec, 100msec, 150msec and 200msec are possible for EXPMAX.

2) Frame time should be not the multiple of 1/100sec and 1/120sec for auto flicker cancellation.

3) HBLANK should be set to meet following equations for auto flicker cancellation

Equation1) $(EXP100[0x3B,3C:P3] * 8 * T_{OPCLK}) / \text{Line Time}$ should be integer.

Equation2) $(EXP120[0x3D,3E:P3] * 8 * T_{OPCLK}) / \text{Line Time}$ should be integer.

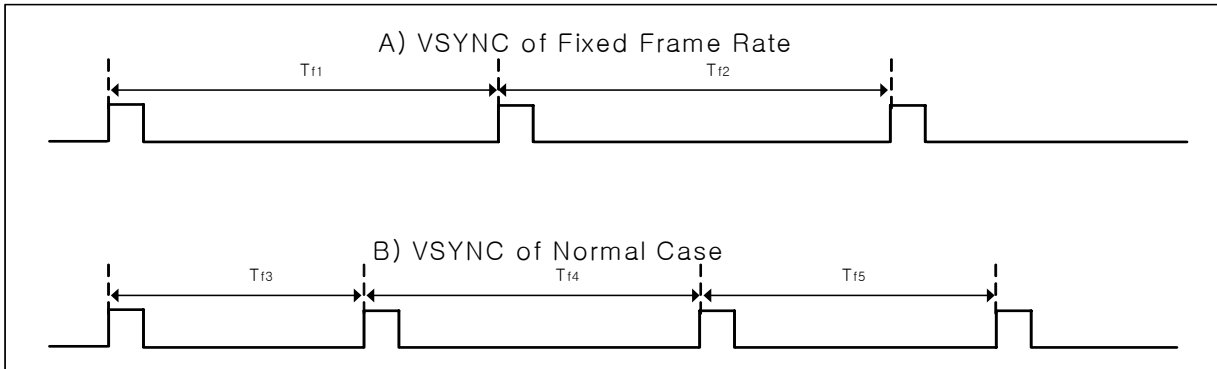
where Line Time = $(1044 + HBLANK) * T_{OPCLK}$, for preview2,

= $(2080 + HBLANK) * T_{OPCLK}$, elsewhere

Fixed Frame Time	
Case1	Condition : $EXPMAX[0x38, 0x39, 0x3A:P3] \leq (\text{Horizontal Width} + HBLANK [0x1B,0x1C:P0]) * \text{Vertical Line} * T_{OPCLK}$
	$EXPFIX[0x41, 0x42, 0x43:P3] \geq (\text{Horizontal Width} + HBLANK) * \text{Vertical Line} * T_{OPCLK} + 10(8.3333)\text{msec} + 24 * T_{OPCLK}$ where Horizontal Width is 2080 for full size and preview1, and 1044 for preview2. where Vertical Line is 1564 for full size, 784 for preview1 and preview2. where 8.333msec for 120Hz flicker cancellation and 10msec for 100Hz flicker cancellation. Frame time = $EXPFIX[0x44, 0x45, 0x46:P3] + (\text{Horizontal Width} + HBLANK) * VSYNC[0x1D, 0x1E:P0] * T_{OPCLK}$ Note) AECTL5[0x314:P3] should be set to 0x40.
Case 2	Condition : $EXPMAX > (\text{Horizontal Width} + HBLANK) * \text{Vertical Line} * T_{OPCLK}$ & The max change step of exposure time is over 10(8.3333)msec
	$EXPFIX \geq 1.25 * EXPMAX[0x41, 0x42, 0x43] + 24 * T_{OPCLK}$ Frame time = $EXPFIX + (\text{Horizontal Width} + HBLANK) * VSYNC * T_{OPCLK}$
Case 3	Condition : $EXPMAX > (\text{Horizontal Width} + HBLANK) * \text{Vertical Line} * T_{OPCLK}$ & The max change step of exposure time is the 10(8.3333)msec
	$EXPFIX \geq EXPMAX + 10(8.333)\text{msec} + 24 * T_{OPCLK}$ Frame time = $EXPFIX + (\text{Horizontal Width} + HBLANK) * VSYNC * T_{OPCLK}$ Note) AECTL5[0x314:P3] should be set to 0x40.
Variable Frame Time	
Case 1	Condition : $EXPINT[0x44:45,46:P3] \leq (\text{Horizontal Width} + HBLANK) * \text{Vertical Line} * T_{OPCLK}$
	Frame time = $(\text{Horizontal Width} + HBLANK) * (\text{Vertical Line} + VSYNC) * T_{OPCLK}$
Case 2	Condition : $EXPINT > (\text{Horizontal Width} + HBLANK [0x88,0x89]) * \text{Vertical Line} * T_{OPCLK}$
	Frame time = $EXPINT + (\text{Horizontal Width} + HBLANK) * VSYNC * T_{OPCLK}$

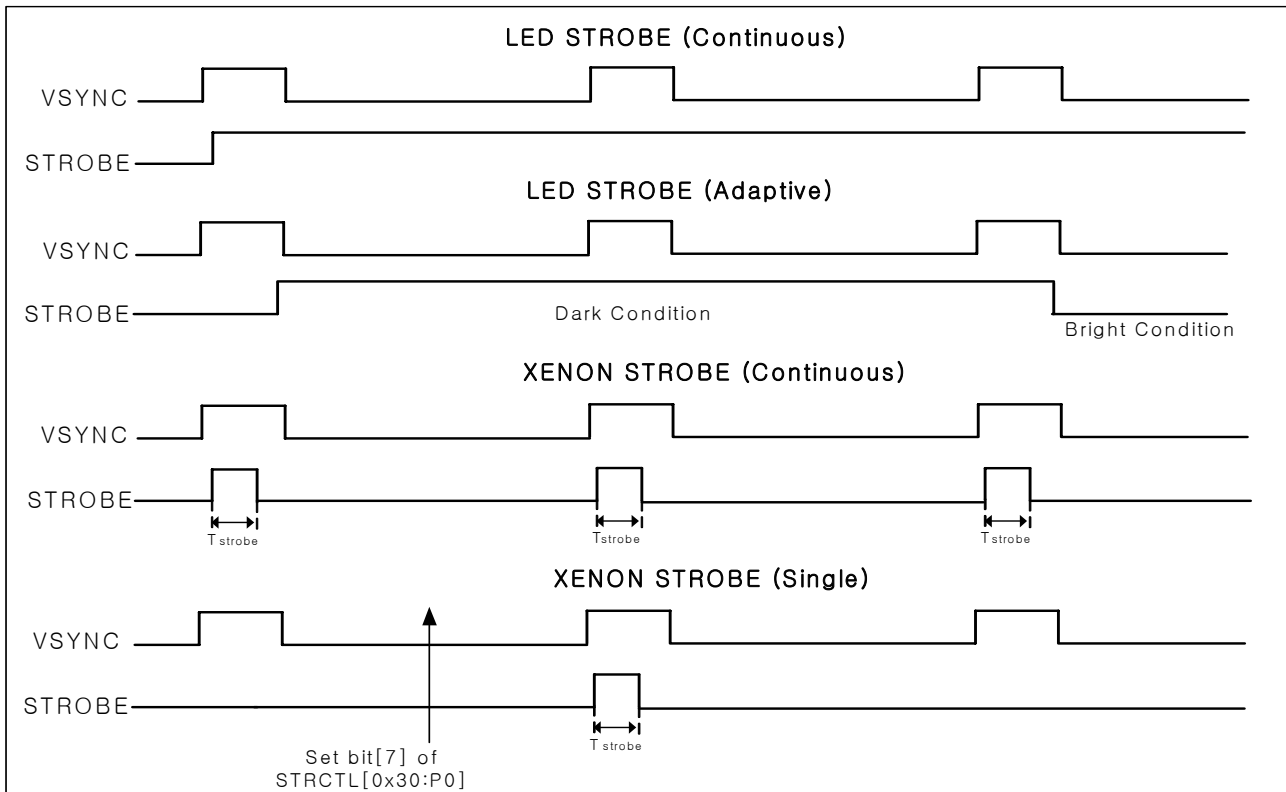
In below figure, T_{f1} is always same as T_{f2} . However, T_{f3} and T_{f4} and T_{f5} are related to the change of exposure time.

<Figure 31. Timing of Fixed Frame Rate >



5.18. Strobe Timing

<Figure 32. Timing of Strobe>



Because sensor can't get good quality image at very low light condition despite long exposure time and large gain, strobe control is needed.

Sensor has the 4type output of strobe pulse, when bit[3] of VDOCTL2[0x11:P0] is ON.

Type1) Continuous LED Strobe

Strobe pulse is always enabled regardless of environment condition, when bit[5] of STRCTL[0x30:P0] is enabled

Type2) Adaptive LED Strobe

Strobe pulse depends on the environment condition, when bit[6] of STRCTL[0x30:P0] is enabled

At dark condition, strobe pulse is enabled, and is disabled at dark condition.

User can define dark condition and bright condition by adjusting STRTIME[0x32:P0].

Type3) Continuous XENON Strobe

Strobe pulse is enabled near to every VSYNC at dark condition, when bit[4] of STRCTL[0x30:P0] is enabled

User can control the width of strobe pulse by adjusting SRTWID[0x31:P0].

Type4) Single XENON Strobe

Strobe pulse is once enabled when bit[7] of STRCTL[0x30:P0] is enabled.

To get strobe pulse at next frame, user should set bit[7] of STRCTL[0x30:P0] again.

5.19. Power Timing

Power On Sequence

VDD 2.8V(ON) -> VDD 1.8V(ON) -> CHIP_ENABLE(ON) -> MCLK(ON) -> RESETB(ON) ->

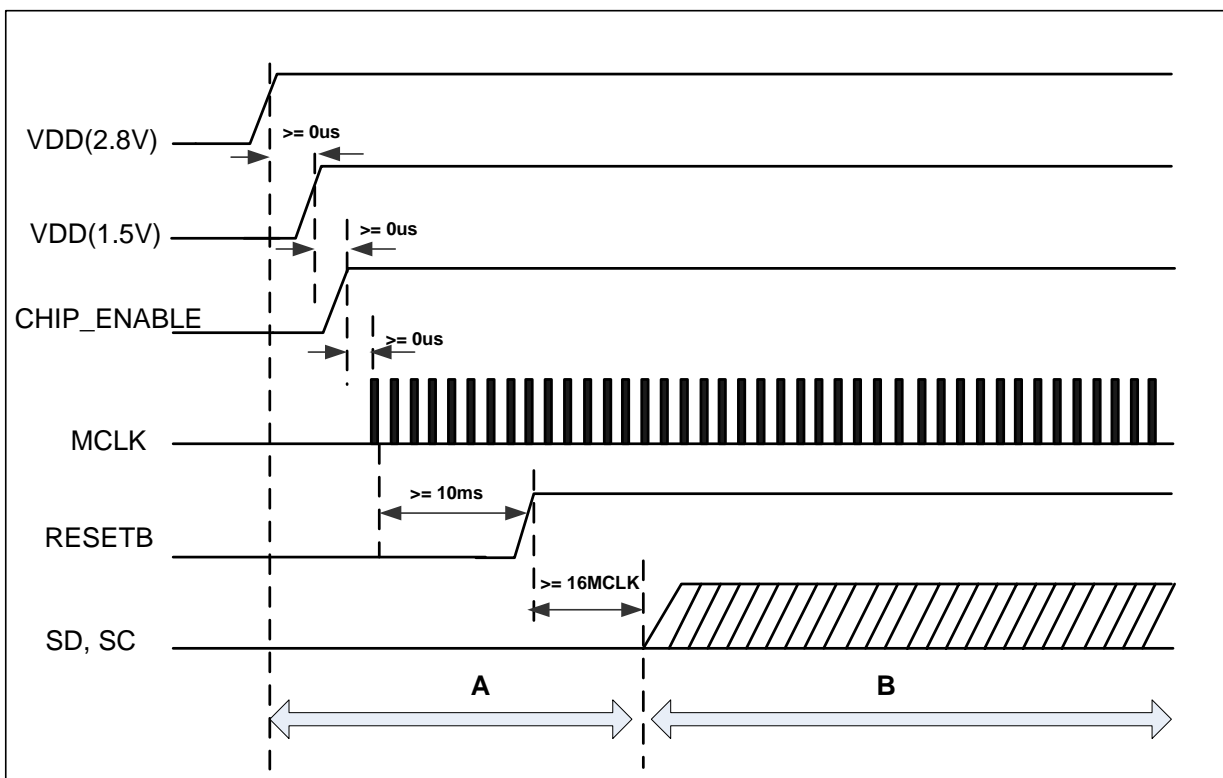
Set Software reset register(Toggle bit[1] of PWRCTL[0x01:P0] : Low -> Hi -> Low) ->

Set registers for normal operation -> Normal Operation

If possible, we recommend that VDD(2.8V) and VDD(1.5V) are supplied at same time.

If the power sequence of VDD:I(2.8V) and VDD:A(2.8V) are separated, VDD:I should be supplied firstly.

<Figure 33. Timing of Power On Sequence>



Period	VSYNC	HSYNC	D[7:0]	PCLK	STROBE	Note
A	Unknown	Unknown	Unknown	Unknown	Unknown	
B	High or Low	High or Low	Hi-Z	High or Low	High or Low	1)
	High or Low	High or Low	High or Low	High or Low	High or Low	2)
	High or Low	High or Low	High or Low	High or Low	High or Low	3)
	Hi-Z	Hi-Z	Hi-Z	Hi-Z	Hi-Z	4)

Note 1) Output pin state of "B" period when HSYNC is invalid and ITU656-like mode is not selected

Note 2) Output pin state of "B" period when HSYNC is invalid and ITU656-like mode is selected

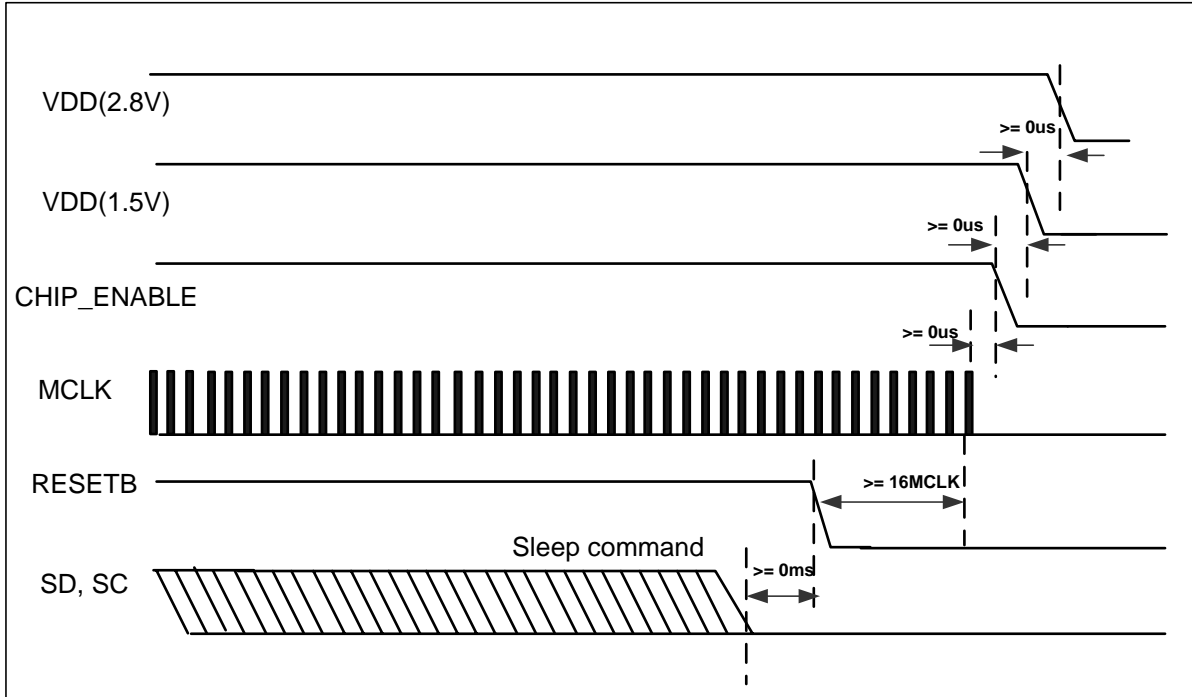
Note 3) Output pin state of "B" period when HSYNC is valid.

Note 4) The state of output pins goes to Hi-Z by setting power sleep in "B" period

Power Off Sequence

Normal Operation -> Power Sleep command and disable PLL -> SC, SD (OFF) -> RESETB(OFF) -> MCLK (OFF) -> CHIP_ENABLE(OFF) -> VDD 1.5V(OFF) -> VDD 2.8V(OFF)

<Figure 34. Timing of Power Off Sequence>

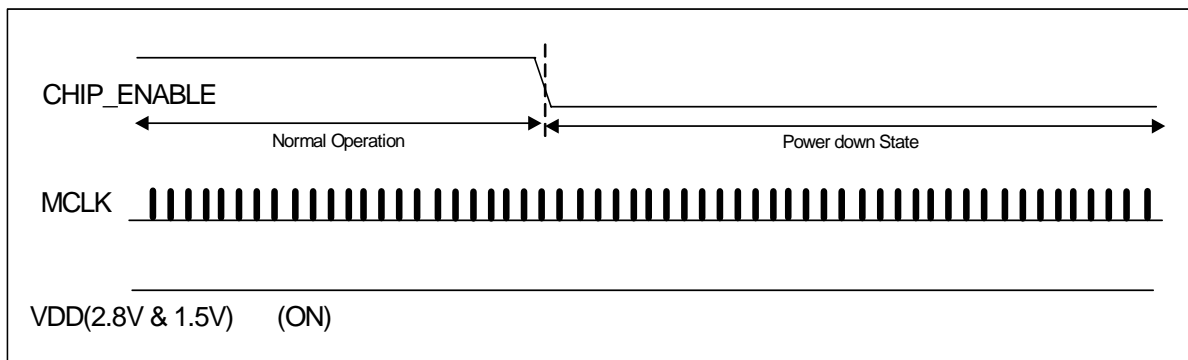


From Normal Operation State to Stand-by(Power down) State

When CHIP_ENABLE is disabled, output pins go to Hi-Z.

Before CHIP_ENABLE is disabled, user should set power sleep and disable PLL through the two wire serial bus.

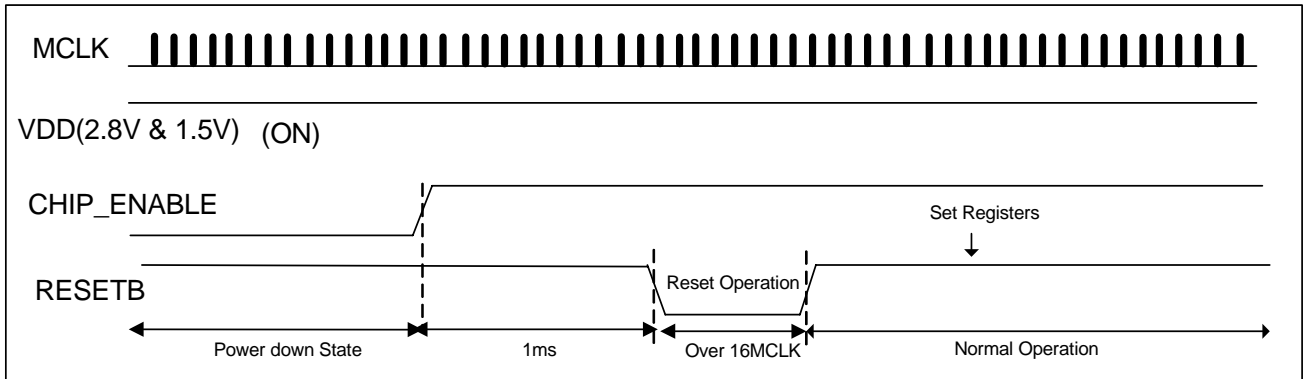
<Figure 35. Timing of Normal Operation to Stand-by >



From Stand-by(Power down) State to Normal Operation State

- 1) Set CHIP_ENABLE to Hi.
- 2) Wait 1ms.
- 3) Set RESETB from Low to Hi.
- 4) Set the software reset register(Toggle bit[1] of PWRCTL[0x01:P0] : Low -> Hi -> Low))
- 5) Set the registers for normal operation

<Figure 36. Timing of Stand-by to Normal Operation>



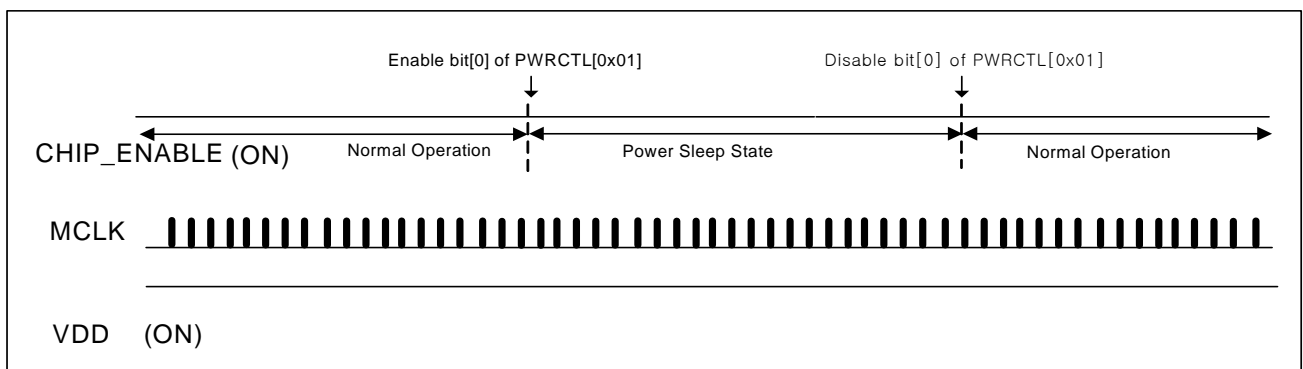
From Normal Operation State to Power Sleep State

Set the PWRCTL[0x01:P0]'s bit[0] to low and disable PLL.

From Power Sleep State to Normal Operation State

Set PWRCTL[0x01:P0]'s bit[0] to Hi.

<Figure 37. Timing of Power Sleep to Normal Operation>



6. REGISTER DESCRIPTION

[Table 9. Register Description]

sensor address in two-wire serial bus : 40H(write) , 41H(read) RO[read only]				
Address (Hex)	Register	Description	Default (Hex)	Renewal Frame
Common Group				
0x03	PAGEMODE	0 = control image size, windowing, sync, black level calibration, strobe 1 = control image format, image effect, edge enhancement, color correction, and gamma correction 2 = control image scaling, auto flicker cancellation, auto focus data, , and lens shading correction 3 = control auto exposure 4 = control auto white balance	0x00	Current
Device ID and Image Size and Windowing and Sync (Page Mode = 0)				
0x01	PWRCTL	Power sleep mode	0x00	Current
0x02	PLLCTL1	Control PLL(Phase Locked Loop)	0x00	Current
0x04	DEVID	Device ID1	0x71(RO)	
0x05		Reserved	RO	
0x06		Reserved	RO	
0x07		Reserved	0x00	Next
0x08	PLLCTL2	Control PLL(Phase Locked Loop)	0x2B	Current
0x09	PLLCTL3	Control PLL(Phase Locked Loop)	0x00	Current
0x0A	PLLCTL4	Control PLL(Phase Locked Loop)	0x00	Current
0x10(P0)	VDOCTL1	Control sub-sampling, preview and vsync type	0x00	Next
0x11(P0)	VDOCTL2	Control strobe, windowing, fixed frame rate, X/Y flip and skip frame	0x90	Next
0x12(P0)	SYNCCTL	Control polarity of H/VSYNC and PCLK, and Internal clock divider	0x04	Next
0x13(P0)	WINROWH	High byte of row start address for windowing	0x00	Next
0x14(P0)	WINROWL	Low byte of row start address for windowing	0x00	Next
0x15(P0)	WINCOLH	High byte of column start address for windowing	0x00	Next
0x16(P0)	WINCOLL	Low byte of column start address for windowing	0x00	Next
0x17(P0)	WINHGTH	High byte of height for windowing	0x06	Next
0x18(P0)	WINHGTL	Low byte of height for windowing	0x00	Next
0x19(P0)	WINWIDH	High byte of width for windowing	0x08	Next
0x1A(P0)	WINWIDL	Low byte of width for windowing	0x00	Next
0x1B(P0)	HBLANKH	High byte of duration for horizontal blanking	0x00	Next
0x1C(P0)	HBLANKL	Low byte of duration for horizontal blanking	0xC4	Next
0x1D(P0)	VSYNCH	High byte of duration for vertical synchronization(Type1)	0x00	Next
0x1E(P0)	VSYNCL	Low byte of duration for vertical synchronization(Type1)	0x14	Next
0x1F(P0)	VSCLIP	Clipping duration in vertical synchronization	0x09	Current
Black level calibration (Page Mode = 0)				
0x20(P0)	BLCCTL1	Control optical black level calibration	0xA8	Next
0x21(P0)	BLCCTL2	Control optical black level calibration	0x00	Current
0x22(P0)	DOFSR	Red color offset at dark condition	0x00	Current
0x23(P0)	DOFSG	Green color offset at dark condition	0x00	Current
0x24(P0)	DOFSB	Blue color offset at dark condition	0x00	Current
0x25(P0)	AOFSR	Manual red color offset	0x00	Current
0x26(P0)	AOFSG	Manual green color offset	0x00	Current
0x27(P0)	AOFSB	Manual blue color offset	0x00	Current
0x28(P0)	CAOFS	Reference for black level calibration	0x20	Current
0x29(P0)		Reserved	RO	
0x2A(P0)		Reserved	RO	



0x2B(P0)		Reserved	RO	
0x2C(P0)		Reserved	0x08	Current
0x2D(P0)		Reserved	0x08	Current
0x2E(P0)	BLCCTL3	Control optical black level calibration	0x00	Current
Strobe (Page Mode = 0)				
0x30(P0)	STRCTL	Control strobe function. (XENON Type and LED Type)	0x09	Current
0x31(P0)	STRWID	Strobe pulse width	0x0C	Current
0x32(P0)	STRTIME	Exposure time to enable strobe function	0x43	Current
0x3A(P0)		Reserved	0x00	Current
0x3B(P0)		Reserved	0xC4	Current
Analog Circuit (Page Mode = 0)				
0x40(P0)		Reserved.	0x77	Current
0x41(P0)		Reserved	0x77	Current
0x42(P0)		Reserved	0x37	Current
0x43(P0)		Reserved	0x10	Current
0x44(P0)		Reserved.	0x10	Current
0x45(P0)		Reserved	0x00	Current
0x47(P0)		Reserved	0x8F	Current
0x48(P0)		Reserved	0x4A	Current
0x49(P0)		Reserved	0x30	Current
0x4A(P0)		Reserved	0x01	Current
0x4B(P0)		Reserved	0x41	Current
0x4C(P0)		Reserved	0x00	Current
0x4D(P0)		Reserved	0x00	Current
0x4E(P0)		Reserved	0x00	Current
0x4F(P0)		Reserved	0x00	Current
0x70(P0)		Reserved	0x00	Current
0x71(P0)		Reserved	0x00	Current
0x72(P0)		Reserved	0x20	Current
0x73(P0)		Reserved	0x00	Current
0x74(P0)		Reserved	0x00	Current
0x75(P0)		Reserved	0x00	Current
0x76(P0)		Reserved	0x0C	Current
0x77(P0)		Reserved	0x80	Current
0x78(P0)		Reserved	0x00	Current
0x79(P0)		Reserved	0x02	Current
0x80(P0)		Reserved	0xCC	Current
0x81(P0)		Reserved	0x01	Current
0x82(P0)		Reserved	0x14	Current
0x83(P0)		Reserved	0x14	Current
0x84(P0)		Reserved	0x02	Current
0x85(P0)		Reserved	0x13	Current
0x86(P0)		Reserved	0x02	Current
0x87(P0)		Reserved	0x13	Current
0x88(P0)		Reserved	0x02	Current
0x89(P0)		Reserved	0x10	Current
0x8A(P0)		Reserved	0x02	Current
0x8B(P0)		Reserved	0x10	Current
0x8D(P0)		Reserved	0x18	Current



0x8E(P0)		Reserved	0x02	Current
0x8F(P0)		Reserved	0x60	Current
0x91(P0)		Reserved	0x06	Current
0x92(P0)		Reserved	0x10	Current
0x93(P0)		Reserved	0x06	Current
0x94(P0)		Reserved	0x10	Current
0x95(P0)		Reserved	0x28	Current
0x96(P0)		Reserved	0x3C	Current
0x97(P0)		Reserved	0x28	Current
0x98(P0)		Reserved	0x3C	Current
0x99(P0)		Reserved	0x12	Current
0x9A(P0)		Reserved	0x24	Current
0x9B(P0)		Reserved	0x40	Current
0x9C(P0)		Reserved	0x5A	Current
0x9D(P0)		Reserved	0x7C	Current
0x9E(P0)		Reserved	0x7D	Current
0x9F(P0)		Reserved	0x88	Current
0xA0(P0)		Reserved	0x88	Current
VSYNC(Type2) (Page Mode = 0)				
0xA1(P0)	VSCTL1	High 4bits of start/stop row position for vertical synchronization(Type2)	0x04	Current
0xA2(P0)	VSCTL2	Low byte of start row position for vertical synchronization(Type2)	0x04	Current
0xA3(P0)	VSCTL3	Low byte of stop row position for vertical synchronization(Type2)	0xB4	Current
0xB0(P0) ~ 0xB7(P0)		Reserved	RO	
0xC0(P0)		Reserved	0x02	
0xC1(P0)		Reserved	0x11	
0xC2(P0)		Reserved	0x02	
0xC3(P0)		Reserved	0x11	
0xC4(P0)		Reserved	0x03	
0xC5(P0)		Reserved	0x5E	
0xC6(P0)		Reserved	0x03	
0xC7(P0)		Reserved	0x5E	
0xC8(P0)		Reserved	0x62	
0xC9(P0)		Reserved	0x10	
0xCA(P0)		Reserved	0x04	
0xCB(P0)		Reserved	0x02	
0xD0(P0)		Reserved	0x01	
0xD1(P0)		Reserved	0x12	
0xD2(P0)		Reserved	0x02	
0xD3(P0)		Reserved	0x5F	
0xE0(P0)		Reserved	0x00	
0xE1(P0)~ 0xE6(P0)		Reserved	RO	
Image Output Format and Image Effect (Page Mode = 1)				
0x10(P1)	ISPCTL1	Control the format of image data	0x03	Next
0x11(P1)	ISPCTL2	Control image effect and color interpolation and color space conversion	0x03	Next
0x12(P1)	ISPCTL3	Control color offset and brightness	0x00	Next
0x13(P1)	ISPCTL4	Control the image effect	0x00	Next
0x14(P1)	ISPCTL5	Control the format of image data	0x00	Current
0x15(P1)		Reserved	0x00	Current



0x16(P1)		Reserved	0x3C	Current
0x19(P1)	YOFS	Offset of luminance	0x00	Next
0x1A(P1)	DYOFS	Offset of luminance at dark condition	0x00	Current
0x1B(P1)	UOFS	Offset of U chrominance	0x00	Next
0x1C(P1)	VOFS	Offset of V chrominance	0x00	Next
0x1D(P1)	UCON	Constant of U chrominance	0x80	Next
0x1E(P1)	VCON	Constant of V chrominance	0x80	Next
0x1F(P1)	SOLARI	Solarization coefficient	0xF0	Next
Color Saturation (Page Mode = 1)				
0x20(P1)	SATCTL	Control color saturation	0x00	Current
0x21(P1)	SATB	Blue color saturation coefficient	0x80	Current
0x22(P1)	SATR	Red color saturation coefficient	0x80	Current
0x23(P1)	BINARY	Threshold of Binary Effect	0x7F	Next
0x24(P1)	CONTRAST	Contrast coefficient	0x80	Next
0x25(P1)	SOLARITH	Threshold of Solarization Effect3	0x7F	Next
0x26(P1)		Reserved	0x80	Next
0x27(P1)		Reserved	0x00	Next
0x28(P1)		Reserved	0x00	Next
0x29(P1)		Reserved	0x00	Next
0x2A(P1)		Reserved	0x00	Next
0x2B(P1)		Reserved	0xF4	Current
0x2C(P1)		Reserved	0x00	Current
0x2D(P1)		Reserved	RO	
0x2E(P1)		Reserved	RO	
Color Correction (Page Mode = 1)				
0x30(P1)	CMCCTL	Control color correction	0x0F	Current
0x32(P1)		Reserved	0x00	Current
0x33(P1)	CMCOFSGH	High threshold of color offset gain	0x40	Current
0x34(P1)	CMCOFSGM	Middle threshold of color offset gain	0x30	Current
0x35(P1)	CMCOFSGL	Low threshold of color offset gain	0x20	Current
0x36(P1)	CMCSIGN	Sign bit of color correction coefficient	0x2F	Current
0x37(P1)		Reserved	0x00	Current
0x38(P1)	CMC11	Color correction coefficient 11	0x4C	Current
0x39(P1)	CMC12	Color correction coefficient 12	0x0C	Current
0x3A(P1)	CMC13	Color correction coefficient 13	0x00	Current
0x3B(P1)	CMC21	Color correction coefficient 21	0x26	Current
0x3C(P1)	CMC22	Color correction coefficient 22	0x80	Current
0x3D(P1)	CMC23	Color correction coefficient 23	0x1A	Current
0x3E(P1)	CMC31	Color correction coefficient 31	0x20	Current
0x3F(P1)	CMC32	Color correction coefficient 32	0x80	Current
0x40(P1)	CMC33	Color correction coefficient 33	0xE0	Current
0x41(P1)	CMCOFSL11	Color correction offset coefficient 11 for low color temperature	0x12	Current
0x42(P1)	CMCOFSL12	Color correction offset coefficient 12 for low color temperature	0xA0	Current
0x43(P1)	CMCOFSL13	Color correction offset coefficient 13 for low color temperature	0x0E	Current
0x44(P1)	CMCOFSL21	Color correction offset coefficient 21 for low color temperature	0x84	Current
0x45(P1)	CMCOFSL22	Color correction offset coefficient 22 for low color temperature	0x08	Current
0x46(P1)	CMCOFSL23	Color correction offset coefficient 23 for low color temperature	0x84	Current
0x47(P1)	CMCOFSL31	Color correction offset coefficient 31 for low color temperature	0x8A	Current
0x48(P1)	CMCOFSL32	Color correction offset coefficient 32 for low color temperature	0x02	Current



0x49(P1)	CMCOFSL33	Color correction offset coefficient 33 for low color temperature	0x08	Current
0x4A(P1)	CMCOFSH11	Color correction offset coefficient 11 for high color temperature	0x12	Current
0x4B(P1)	CMCOFSH12	Color correction offset coefficient 12 for high color temperature	0xA0	Current
0x4C(P1)	CMCOFSH13	Color correction offset coefficient 13 for high color temperature	0x0E	Current
0x4D(P1)	CMCOFSH21	Color correction offset coefficient 21 for high color temperature	0x84	Current
0x4E(P1)	CMCOFSH22	Color correction offset coefficient 22 for high color temperature	0x08	Current
0x4F(P1)	CMCOFSH23	Color correction offset coefficient 23 for high color temperature	0x84	Current
0x50(P1)	CMCOFSH31	Color correction offset coefficient 31 for high color temperature	0x8A	Current
0x51(P1)	CMCOFSH32	Color correction offset coefficient 32 for high color temperature	0x02	Current
0x52(P1)	CMCOFSH33	Color correction offset coefficient 33 for high color temperature	0x08	Current
Gamma Correction (Page Mode = 1)				
0x60(P1)	GMACTL	Control gamma correction	0x01	Current
0x61(P1)	GMA0	Gamma corrected output at 0(0)code in 10(8)bit linear input	0x00	Current
0x62(P1)	GMA1	Gamma corrected output at 16(4)code in 10(8)bit linear input	0x15	Current
0x63(P1)	GMA2	Gamma corrected output at 32(8)code in 10(8)bit linear input	0x1F	Current
0x64(P1)	GMA3	Gamma corrected output at 64(16)code in 10(8)bit linear input	0x30	Current
0x65(P1)	GMA4	Gamma corrected output at 128(32)code in 10(8)bit linear input	0x49	Current
0x66(P1)	GMA5	Gamma corrected output at 192(48)code in 10(8)bit t linear input	0x5D	Current
0x67(P1)	GMA6	Gamma corrected output at 256(64)code in 10(8)bit linear input	0x6F	Current
0x68(P1)	GMA7	Gamma corrected output at 320(80)code in 10(8)bit linear input	0x7F	Current
0x69(P1)	GMA8	Gamma corrected output at 384(96)code in 10(8)bit linear input	0x8E	Current
0x6A(P1)	GMA9	Gamma corrected output at 448(112)code in 10(8)bit linear input	0x9B	Current
0x6B(P1)	GMA10	Gamma corrected output at 512(128)code in 10(8)bit linear input	0xA8	Current
0x6C(P1)	GMA11	Gamma corrected output at 576(144)code in 10(8)bit linear input	0xB5	Current
0x6D(P1)	GMA12	Gamma corrected output at 640(160)code in 10(8)bit linear input	0xC1	Current
0x6E(P1)	GMA13	Gamma corrected output at 704(176)code in 10(8)bit linear input	0xCC	Current
0x6F(P1)	GMA14	Gamma corrected output at 768(192)code in 10(8)bit linear input	0xD7	Current
0x70(P1)	GMA15	Gamma corrected output at 832(208)code in 10(8)bit linear input	0xE2	Current
0x71(P1)	GMA16	Gamma corrected output at 896(224)code in 10(8)bit linear input	0xEC	Current
0x72(P1)	GMA17	Gamma corrected output at 960(240)code in 10(8)bit linear input	0xF6	Current
0x73(P1)	GMA18	Gamma corrected output at 1023(255)code in 10(8)bit linear input	0xFF	Current
Edge Enhancement (Page Mode = 1)				
0x90(P1)	EDGECTL1	Control edge enhancement	0x00	Current
0x91(P1)	EDGECTL2	Control edge enhancement	0x9D	Current
0x92(P1)	EDGECTL3	Control edge enhancement	0x00	Current
0x93(P1)	EDGEGAIN	Edge gain to emphasize edge data at low edge value	0x42	Current
0x94(P1)	EGDEVALTH	Threshold to define high edge value	0x10	Current
0x95(P1)	EDGEWGT1	Weight of emphasizing vertical(horizontal) edge component	0x88	Current
0x96(P1)	EDGEWGT2	Weight of 1 st /2 nd differential	0x55	Current
0x97(P1)	EGDECOMPHTH	Threshold to clip low edge component to calculate edge value	0x0A	Current
0x98(P1)		Reserved	0x75	Current
0x99(P1)	EDGEEXPTH	Threshold of exposure time for edge enhancement	0x10	Current
0x9A(P1)	EDGEAGTH	Threshold of automatic gain for edge enhancement	0x10	Current
0x9B(P1)		Reserved	0x14	Current
0x9C(P1)		Reserved	0x88	Current
0x9D(P1)		Reserved	0x10	Current
0x9E(P1)		Reserved	0x10	Current
Noise Reduction Filter(Page Mode = 1)				
0xA0(P1)	LPFCTL1	Control D-low pass filter	0x00	Current
0xA1(P1)		Reserved	0x04	Current



0xA2(P1)	LPFCTL2	Control Z-low pass filter	0x08	Current
0xA3(P1)	ZLPFCTL	Control Z-low pass filter	0x5D	Current
0xA4(P1)	LPFCTL3	Ratio of threshold on LPF	0xC0	Current
0xA5(P1)	LPFAGTH	Threshold of AG for low pass filter	0x20	Current
0xA6(P1)	LPFEXPTH	Threshold of exposure time for low pass filter	0x10	Current
0xA7(P1)	LPFRGAINTH	Threshold of R gain for low pass filter	0x50	Current
0xA8(P1)		Reserved	0x14	Current
0xA9(P1)		Reserved	0x08	Current
0xAA(P1)	DDIFFTH1	Differential Threshold for D-LPF	0x08	Current
0xAD(P1)	DAGON	AG Threshold to enable D-LPF	0x40	Current
0xAE(P1)	DAGOFF	AG Threshold to disable D-LPF	0x38	Current
0xB0(P1)	DDYCTL1	Control the threshold of dynamic range for D-LPF	0x11	Current
0xB1(P1)	DDYCTL2	Ratio of dynamic range to average for D-LPF	0x44	Current
0xB2(P1)		Reserved	0x38	Current
0xB3(P1)		Reserved	0x38	Current
0xB4(P1)	ZLPFTH1	Threshold1 of Z-LPF.	0x88	Current
0xB5(P1)	ZLPFTH2	Threshold2 of Z-LPF.	0x44	Current
0xB8(P1)		Reserved	0x10	Current
0xB9(P1)		Reserved	0x1D	Current
0xBA(P1)		Reserved	0x2F	Current
0xBC(P1) ~ 0xBF(P1)		Reserved	RO	
Dead Pixel Cancellation (Page Mode = 1)				
0xC0(P1)	DPCCTL	Control DPC	0xC3	Current
0xC1(P1)		Reserved	0x00	Current
0xC2(P1)	DPCTH	Threshold of DPC	0x88	Current
0xC3(P1)		Reserved	0x44	Current
0xC4(P1)		Reserved	0x40	Current
0xC5(P1)		Reserved	0x20	Current
0xC6(P1)		Reserved	0x43	Current
0xC7(P1)		Reserved	0x44	Current
0xC9(P1)		Reserved	0x44	Current
0xCC(P1)		Reserved	0x10	Current
0xCD(P1)		Reserved	0x20	Current
0xCE(P1)		Reserved	0x00	Current
0xCF(P1)		Reserved	RO	
Color Noise Reduction (Page Mode = 1)				
0xD0(P1)	CNR1CTL	Control the color noise reduction method1	0x3F	Current
0xD1(P1)	CNR1GTH	Green color threshold for color noise reduction method1	0x40	Current
0xD2(P1)	CNR1RBTH	Red/Blue color threshold for color noise reduction method1	0x40	Current
0xD3(P1)	CNR1LVL	Threshold for color noise reduction method1	0xC0	Current
0xF0(P1)	CNR2CTL	Control the color noise reduction method2	0x00	Current
0xF1(P1)	CNR2TH	Threshold for color noise reduction method2	0x82	Current
0xF2(P1)	CNR2PARA	Parameter1 for color noise reduction method2	0xAA	Current
0xF3(P1)		Reserved	0xAA	Current
0xF8(P1)	CNR4CTL	Control the color noise reduction method4	0x88	Current
0xF9(P1)	CNR4PARA1	Parameter1 for color noise reduction method4	0x55	Current
0xFA(P1)	CNR4PARA2	Parameter2 for color noise reduction method4	0xAA	Current
0xFB(P1)	CNR4TH	Threshold for color noise reduction method4	0xF7	Current



Image Scaling (Page Mode = 2)				
0x10(P2)	ZOOMCTL1	Control image scaling	0x00	Next
0x11(P2)	ZOOMCTL2	Control image scaling	0x40	Next
0x12(P2)	ZOUTWIDH	High byte of image width for image scaling	0x01	Next
0x13(P2)	ZOUTWIDL	Low byte of image width for image scaling	0x40	Next
0x14(P2)	ZOUTHGTH	High byte of image height for image scaling	0x00	Next
0x15(P2)	ZOUTHGTL	Low byte of image height for image scaling	0xF0	Next
0x16(P2)	ZWINSTXH	High byte of start x position for windowing after image scaling	0x00	Next
0x17(P2)	ZWINSTXL	Low byte of start x position for windowing after image scaling	0x00	Next
0x18(P2)	ZWINSTYH	High byte of start y position for windowing after image scaling	0x00	Next
0x19(P2)	ZWINSTYL	Low byte of start y position for windowing after image scaling	0x00	Next
0x1A(P2)	ZWINENXH	High byte of end x position for windowing after image scaling	0x04	Next
0x1B(P2)	ZWINENXL	Low byte of end x position for windowing after image scaling	0xB0	Next
0x1C(P2)	ZWINENYH	High byte of end y position for windowing after image scaling	0x06	Next
0x1D(P2)	ZWINENYL	Low byte of end y position for windowing after image scaling	0x40	Next
0x1E(P2)	ZVERSTEPH	High byte of vertical scaling step	0x10	Next
0x1F(P2)	ZVERSTEPL	Low byte of vertical scaling step	0x00	Next
0x20(P2)	ZHORSTEPH	High byte of horizontal scaling step	0x10	Next
0x21(P2)	ZHORSTEPL	Low byte of horizontal scaling step	0x00	Next
0x22(P2)	ZFIFODLY	Delay depth for image scaling	0x00	Next
Edge data for Auto Focus (Page Mode = 2)				
0x30(P2)	AFCTL1	Control auto focus filter	0x00	Current
0x31(P2)	AFCTL2	Control auto focus filter	0x00	Current
0x32(P2)	AFCTL3	Control auto focus filter	0x00	Current
0x33(P2)	AFR1XST/ AFROW1	X coordinate of start position for defining region1 of AF type0/ Row address1 for defining region of AF type1	0x10	Current
0x34(P2)	AFR1YST/ AFROW2	Y coordinate of start position for defining region1 of AF type0/ Row address2 for defining region of AF type1	0x3B	Current
0x35(P2)	AFR1XEN/ AFROW3	X coordinate of end position for defining region1 of AF type0/ Row address3 for defining region of AF type1	0x5B	Current
0x36(P2)	AFR1YEN	Y coordinates of end position for defining region1 of AF type0/	0x80	Current
0x37(P2)	AFR2XST/ AFCOL1	X coordinate of start position for defining region2 of AF type0/ Column address1 for defining region of AF type1	0x10	Current
0x38(P2)	AFR2YST/ AFCOL2	Y coordinate of start position for defining region2 of AF type0/ Column address2 for defining region of AF type1	0x54	Current
0x39(P2)	AFR2XEN/ AFCOL3	X coordinate of end position for defining region2 of AF type0/ Column address3 for defining region of AF type1	0x74	Current
0x3A(P2)	AFR2YEN	Y coordinates of end position for defining region2 of AF type0	0x80	Current
0x3B(P2)	AFCLIPTH	Threshold for clipping high value to get AF data	0xFE	Current
0x3C(P2)	AFDRVCTL1	Control Current Driver for Auto Focus	0x00	Current
0x3D(P2)	AFDRVCTL2	Control Current Driver for Auto Focus	0x00	Current
0x3E(P2)	AFVAL1R1H/ AFEDGE1H	High byte of edge data1 in region1 for AF type0 High byte of edge data in region1 for AF type1	RO	Previous
0x3F(P2)	AFVAL1R1L/ AFEDGE1L	Low byte of edge data1 in region1 for AF type0 Low byte of edge data in region1 for AF type1	RO	Previous
0x40(P2)	AFVAL2R1H/ AFEDGE2H	High byte of edge data2 in region1 for AF type0 High byte of edge data in region2 for AF type1	RO	Previous
0x41(P2)	AFVAL2R1L/ AFEDGE2L	Low byte of edge data2 in region1 for AF type0 Low byte of edge data in region2 for AF type1	RO	Previous
0x42(P2)	AFVAL1R2H/ AFEDGE4H	High byte of edge data1 in region2 for AF type0 High byte of edge data in region4 for AF type1	RO	Previous
0x43(P2)	AFVAL1R2L/ AFEDGE4L	Low byte of edge data1 in region2 for AF type0 Low byte of edge data in region4 for AF type1	RO	Previous
0x44(P2)	AFVAL2_R2H/ AFEDGE5H	High byte of edge data2 in region2 for AF type0 High byte of edge data in region5 for AF type1	RO	Previous
0x45(P2)	AFVAL2R2L/ AFEDGE5L	Low byte of edge data2 in region2 for AF type0 Low byte of edge data in region5 for AF type1	RO	Previous
0x46(P2)	AFVAL3R1H/ AFEDGE3H	High byte of edge data3 in region1 for AF type0 High byte of edge data in region3 for AF type1	RO	Previous
0x47(P2)	AFVAL3R1L/ AFEDGE3L	Low byte of edge data3 in region1 for AF type0 Low byte of edge data in region3 for AF type1	RO	Previous



0x48(P2)	AFVAL3R2H	High byte of edge data3 in region2 for AF type0	RO	Previous
0x49(P2)	AFVAL3R2L	Low byte of edge data3 in region2 for AF type0	RO	Previous
0x4A(P2)	YSUMR1H	High byte of summed luminance in region1 for AF type0	RO	Previous
0x4B(P2)	YSUMR1M	Middle byte of summed luminance in region1 for AF type0	RO	Previous
0x4C(P2)	YSUMR1L	Low byte of summed luminance in region1 for AF type0	RO	Previous
0x4D(P2)	YSUMR2H	High byte of summed luminance in region2 for AF type0	RO	Previous
0x4E(P2)	YSUMR2M	Middle byte of summed luminance in region2 for AF type0	RO	Previous
0x4F(P2)	YSUMR2L	Low byte of summed luminance in region2 for AF type0	RO	Previous
Auto Flicker Cancellation (Page Mode = 2)				
0x50(P2)	FLKMODE	Number of skipped frames in AFC operation	0x00	Current
0x51(P2)	FLK200	Number of horizontal line for 1/200sec	0x42	Current
0x52(P2)	FLK240	Number of horizontal line for 1/240sec	0x37	Current
0x53(P2)	FLKTH1	Low threshold to detect flicker noise	0x02	Current
0x54(P2)	FLKTH2	High threshold to detect flicker noise	0x20	Current
0x55(P2)	FLKDET	Internal flicker detection state in AFC	RO	Current
0x56~0x5A		Reserved	RO	
Image Statistics (Page Mode = 2)				
0x60(P2)	ISCTL1	Control Image Statistics	0xF2	Current
0x61(P2)	ISCTL2	Control Image Statistics	0x07	Current
0x62(P2)		Reserved	0x10	Current
0x63(P2)		Reserved	0xD0	Current
0x64(P2)		Reserved	0x4C	Current
0x65(P2)		Reserved	0x42	Current
0x66(P2)		Reserved	0x33	Current
0x67(P2)		Reserved	0x40	Current
0x68(P2)		Reserved	0x3F	Current
0x69(P2)		Reserved	0x22	Current
0x6A(P2)		Reserved	0x10	Current
0x6B(P2)		Reserved	0x00	Current
0x70(P2)		Reserved	0xC4	Current
0x71(P2)		Reserved	0xC4	Current
0x72(P2)		Reserved	0xC4	Current
0x73(P2)		Reserved	0x36	Current
0x74(P2)		Reserved	0x36	Current
0x75(P2)		Reserved	0x25	Current
0x76(P2)		Reserved	0x0E	Current
0x77(P2)		Reserved	0x39	Current
0x78(P2)		Reserved	0xDC	Current
0x79(P2)		Reserved	0xBA	Current
0x7A(P2)		Reserved	0xCB	Current
0x7B(P2)		Reserved	0xAC	Current
0x7C(P2)		Reserved	0x00	Current
0x7D(P2)		Reserved	0xD6	Current
0x7E(P2)		Reserved	0x2A	Current
0x7F(P2)		Reserved	0xF4	Current
0x80(P2)		Reserved	0xEE	Current
0x81(P2)		Reserved	0x65	Current
0x82(P2)		Reserved	0x3E	Current
0x83(P2)		Reserved	0xC0	Current



0x84(P2)		Reserved	0x3F	Current
0x85(P2)		Reserved	0x18	Current
0x86(P2)		Reserved	0xC3	Current
0x87(P2)		Reserved	0x68	Current
0x88(P2)		Reserved	0xAD	Current
0x89(P2)		Reserved	0xCB	Current
0x8A(P2)		Reserved	0xB4	Current
0x8B(P2)		Reserved	0x3C	Current
0x8C(P2)		Reserved	0x0A	Current
0x90(P2) ~ 0x9F(P2)		Reserved	RO	
Lens Shading Correction (Page Mode = 2)				
0xA0(P2)	LENSCTL1	Control lens shading correction	0x00	Current
0xA1(P2)	LENSCTL2	Control lens shading correction	0x0B	Current
0xA2(P2)	XCEN	Optical center on X-axis in pixel array for lens shading correction	0x80	Current
0xA3(P2)	YCEN	Optical center on Y-axis in pixel array for lens shading correction	0x80	Current
0xA4(P2)		Reserved	0x20	Current
0xA5(P2)		Reserved	0x40	Current
0xA6(P2)	LENSGrP1	Lens Shading Correction Gain Parameter1 for Gr Pixel	0x0A	Current
0xA7(P2)	LENSGrP2	Lens Shading Correction Gain Parameter2 for Gr Pixel	0x20	Current
0xA8(P2)	LENSGrP3	Lens Shading Correction Gain Parameter3 for Gr Pixel	0x30	Current
0xA9(P2)	LENSGrP4	Lens Shading Correction Gain Parameter4 for Gr Pixel	0x40	Current
0xAA(P2)	LENSGrP5	Lens Shading Correction Gain Parameter5 for Gr Pixel	0x50	Current
0xAB(P2)	LENSGrP6	Lens Shading Correction Gain Parameter6 for Gr Pixel	0x60	Current
0xAC(P2)	LENSGrP7	Lens Shading Correction Gain Parameter7 for Gr Pixel	0x70	Current
0xAD(P2)	LENSGrP8	Lens Shading Correction Gain Parameter8 for Gr Pixel	0x70	Current
0xAE(P2)	LENSRP1	Lens Shading Correction Gain Parameter1 for Red Pixel	0x0A	Current
0xAF(P2)	LENSRP2	Lens Shading Correction Gain Parameter2 for Red Pixel	0x20	Current
0xB0(P2)	LENSRP3	Lens Shading Correction Gain Parameter3 for Red Pixel	0x30	Current
0xB1(P2)	LENSRP4	Lens Shading Correction Gain Parameter4 for Red Pixel	0x40	Current
0xB2(P2)	LENSRP5	Lens Shading Correction Gain Parameter5 for Red Pixel	0x50	Current
0xB3(P2)	LENSRP6	Lens Shading Correction Gain Parameter6 for Red Pixel	0x60	Current
0xB4(P2)	LENSRP7	Lens Shading Correction Gain Parameter7 for Red Pixel	0x70	Current
0xB5(P2)	LENSRP8	Lens Shading Correction Gain Parameter8 for Red Pixel	0x70	Current
0xB6(P2)	LENSGbP1	Lens Shading Correction Gain Parameter1 for Gb Pixel	0x0A	Current
0xB7(P2)	LENSGbP2	Lens Shading Correction Gain Parameter2 for Gb Pixel	0x20	Current
0xB8(P2)	LENSGbP3	Lens Shading Correction Gain Parameter3 for Gb Pixel	0x30	Current
0xB9(P2)	LENSGbP4	Lens Shading Correction Gain Parameter4 for Gb Pixel	0x40	Current
0xBA(P2)	LENSGbP5	Lens Shading Correction Gain Parameter5 for Gb Pixel	0x50	Current
0xBB(P2)	LENSGbP6	Lens Shading Correction Gain Parameter6 for Gb Pixel	0x60	Current
0xBC(P2)	LENSGbP7	Lens Shading Correction Gain Parameter7 for Gb Pixel	0x70	Current
0xBD(P2)	LENSGbP8	Lens Shading Correction Gain Parameter8 for Gb Pixel	0x70	Current
0xBE(P2)	LENSBP1	Lens Shading Correction Gain Parameter1 for Blue Pixel	0x0A	Current
0xBF(P2)	LENSBP2	Lens Shading Correction Gain Parameter2 for Blue Pixel	0x20	Current
0xC0(P2)	LENSBP3	Lens Shading Correction Gain Parameter3 for Blue Pixel	0x30	Current
0xC1(P2)	LENSBP4	Lens Shading Correction Gain Parameter4 for Blue Pixel	0x40	Current
0xC2(P2)	LENSBP5	Lens Shading Correction Gain Parameter5 for Blue Pixel	0x50	Current
0xC3(P2)	LENSBP6	Lens Shading Correction Gain Parameter6 for Blue Pixel	0x60	Current
0xC4(P2)	LENSBP7	Lens Shading Correction Gain Parameter7 for Blue Pixel	0x70	Current
0xC5(P2)	LENSBP8	Lens Shading Correction Gain Parameter8 for Blue Pixel	0x70	Current
0xC6(P2)		Reserved	0x00	Current



0xC7(P2)		Reserved	0x00	Current
0xC8(P2)		Reserved	0x00	Current
0xC9(P2)		Reserved	0x00	Current
0xCA(P2)		Reserved	0x00	Current
0xCB(P2)		Reserved	0x00	Current
0xCC(P2)		Reserved	0x00	Current
0xCD(P2)		Reserved	0x00	Current
0xCE(P2)		Reserved	0x00	Current
0xCF(P2)		Reserved	0x00	Current
0xD0(P2)		Reserved	0x00	Current
0xD1(P2)		Reserved	0x00	Current
0xD2(P2)		Reserved	0x00	Current
0xD3(P2)		Reserved	0x00	Current
0xD4(P2)		Reserved	0x00	Current
0xD5(P2)		Reserved	0x00	Current
0xD6(P2)	LAGOFF	AG threshold to disable Lens Shading Correction Gain	0x60	Current
0xD7(P2)	LAGON	AG threshold to enable Lens Shading Correction Gain	0x60	Current
0xD8(P2)		Reserved	0x90	Current
0xD9(P2)		Reserved	0x00	Current
0xDA(P2)		Reserved	0x00	Current
Auto Exposure (Page Mode = 3)				
0x10(P3)	AECTL1	Control automatic exposure	0x0C	Next
0x11(P3)	AECTL2	Control automatic exposure	0x80	Next
0x12(P3)	AECTL3	Control automatic exposure	0x30	Current
0x13(P3)	AECTL4	Control automatic exposure	0xA5	Current
0x14(P3)	AECTL5	Control automatic exposure	0x30	Current
0x15(P3)	AECTL6	Control automatic exposure	0x51	Current
0x16(P3)	AECTL7	Control automatic exposure	0x07	Current
0x17(P3)	AECTL8	Control automatic exposure	0x25	Current
0x18(P3)		Reserved	0x00	Current
0x19(P3)	AECTL9	Control automatic exposure	0x70	Current
0x1A(P3)		Reserved	0x5C	Current
0x1B(P3)		Reserved	0x45	Current
0x1C(P3)	YLVL	Luminance level to converge in AE	0x50	Current
0x1D(P3)	YTH1	Threshold1 of hysteresis in AE	0x45	Current
0x1E(P3)	YTH2	Threshold2 of hysteresis in AE	0x28	Current
0x1F(P3)		Reserved	0xFF	Current
0x20(P3)	AHXOFS	Horizontal x start position to divide image area	0x04	Current
0x21(P3)	AVYOFS	Vertical y start position to divide image area	0x04	Current
0x22(P3)	AHWID1	Horizontal width1 of divided image area	0xFB	Current
0x23(P3)	AVHGT1	Vertical height1 of a divided image area	0xA7	Current
0x24(P3)	AHWID2	Horizontal width2 for a divided image area	0xFD	Current
0x25(P3)	AVHGT2	Vertical height2 for a divided image area	0xA9	Current
0x26(P3)	AEWGT	Weight coefficient of each AE region	0x95	Current
0x2A(P3)		Reserved	0x00	Current
0x2B(P3)		Reserved	0x44	Current
0x2C(P3)		Reserved	0xC0	Current
0x30(P3)	EXPINTH	High byte of internal exposure time	RO	Current
0x31(P3)	EXPINTM	Middle byte of internal exposure time	RO	Current
0x32(P3)	EXPINTL	Low byte of internal exposure time	RO	Current



0x33(P3)	EXPTIMEH	High byte of manual exposure time	0x01	Next
0x34(P3)	EXPTIMEM	Middle byte of manual exposure time	0x86	Next
0x35(P3)	EXPTIMEL	Low byte of manual exposure time	0xA0	Next
0x36(P3)	EXPMINH	High byte of minimum exposure time	0x01	Current
0x37(P3)	EXPMINL	Low byte of minimum exposure time	0xC8	Current
0x38(P3)	EXPMAXH	High byte of maximum exposure time	0x09	Current
0x39(P3)	EXPMAXM	Middle byte of maximum exposure time	0x27	Current
0x3A(P3)	EXPMAXL	Low byte of maximum exposure time	0xC0	Current
0x3B(P3)	EXP100H	High byte of exposure time for 1/100sec	0x75	Next
0x3C(P3)	EXP100L	Low byte of exposure time for 1/100sec	0x30	Next
0x3D(P3)	EXP120H	High byte of exposure time for 1/120sec	0x61	Next
0x3E(P3)	EXP120L	Low byte of exposure time for 1/120sec	0xA8	Next
0x3F(P3)	EXPDPCH	High byte of exposure time for dead pixel concealment	0x04	Current
0x40(P3)	EXPDPCL	Low byte of exposure time for dead pixel concealment	0x93	Current
0x41(P3)	EXPFIXH	High byte of exposure time for fixed frame rate	0x12	Current
0x42(P3)	EXPFIXM	Middle byte of exposure time for fixed frame rate	0x4F	Current
0x43(P3)	EXPFIXL	Low byte of exposure time for fixed frame rate	0x80	Current
0x44(P3)	EXPINCH	High byte of maximum exposure time for fixed frame rate	RO	Current
0x45(P3)	EXPINCM	Middle byte of maximum exposure time for fixed frame rate	RO	Current
0x46(P3)	EXPINCL	Low byte of maximum exposure time for fixed frame rate	RO	Current
0x47(P3)		Reserved	0x01	Current
0x48(P3)	BRTTIMETH	Threshold of exposure time to define bright condition.	0x9A	Current
0x49(P3)		Reserved	0x45	Current
0x4A(P3)		Reserved	0x78	Current
0x4B(P3)		Reserved	0xD5	Current
0x4C(P3)	EXPFINEH	High byte of fine exposure time	0x09	Current
0x4D(P3)	EXPFINEL	Low byte of fine exposure time	0xC4	Current
0x4E(P3)	AECTL10	Control automatic exposure	0x01	Current
0x4F(P3)		Reserved	0x0C	Current
0x50(P3)	AG	Automatic gain (AG)	0x10	Next
0x51(P3)	AGMIN	Minimum AG in AE	0x10	Current
0x52(P3)	AGMAX	Maximum AG in AE	0x80	Current
0x53(P3)	AGLVL	Target level of AG in AE	0x10	Current
0x54(P3)	AGTH1	Minimum threshold of Band AG in AE	0x10	Current
0x55(P3)	AGTH2	Maximum threshold of Band AG in AE	0x33	Current
0x56(P3)	AGDPC	Threshold of AG in DPC (Dead Pixel Concealment)	0x60	Current
0x57(P3)	AGSAT	Threshold of AG in auto saturation	0x60	Current
0x58(P3)	AGBRT	Threshold of AG in auto bright	0x60	Current
0x59(P3)	AGBTH1	Threshold1 of Adaptive AG in AE.	0x22	Current
0x5A(P3)	AGBTH2	Threshold2 of Adaptive AG in AE.	0x1C	Current
0x5B(P3)	AGBTH3	Threshold3 of Adaptive AG in AE.	0x19	Current
0x5C(P3)	AGBTH4	Threshold4 of Adaptive AG in AE.	0x17	Current
0x5D(P3)	AGBTH5	Threshold5 of Adaptive AG in AE.	0x15	Current
0x5E(P3)	AGBTH6	Threshold6 of Adaptive AG in AE.	0x14	Current
0x5F(P3)	AGBTH7	Threshold7 of Adaptive AG in AE.	0x13	Current
0x60(P3)	AGBTH8	Threshold8 of Adaptive AG in AE.	0x12	Current
0x61(P3)		Reserved	0x14	Current
0x64(P3)		Reserved	0x45	Current
0x65(P3)		Reserved	0x88	Current



0x66(P3)		Reserved	0x82	Current
0x67(P3)		Reserved	0x54	Current
0x68(P3)		Reserved	0x0C	Current
0x69(P3)		Reserved	0x86	Current
0x6D(P3)		Reserved	0x09	Current
0x6E(P3)		Reserved	0x27	Current
0x6F(P3)		Reserved	0xC0	Current
0xD3	YAVG	Average of luminance in frame	RO	
0xD0~0xEA		Reserved	RO	
Auto White Balance (Page Mode = 4)				
0x10(P4)	AWBCTL1	Control automatic white balance	0x6B	Next
0x11(P4)	AWBCTL2	Control automatic white balance	0x28	Next
0x12(P4)		Reserved	0x00	Current
0x13(P4)		Reserved	0x00	Current
0x14(P5)		Reserved	0x09	Current
0x17(P4)		Reserved	0xC0	Current
0x18(P4)		Reserved	0xAC	Current
0x19(P4)		Reserved	0xFF	Current
0x1F(P5)		Reserved	0xA8	Current
0x20(P4)	UVTH1	U/V chrominance threshold1 in AWB	0x13	Current
0x21(P4)	UVTH2	U/V chrominance threshold2 in AWB	0x66	Current
0x22(P4)		Reserved	0x88	Current
0x23(P4)	YRANGE	Valid luminance range in AWB	0x88	Current
0x24(P4)	CDIFF	Threshold1 of chrominance difference	0x88	Current
0x25(P4)	CSUM	Threshold1 of chrominance summation	0x66	Current
0x26(P4)		Reserved	0x88	Current
0x27(P4)		Reserved	0x66	Current
0x2A(P4)		Reserved	0x88	Current
0x2B(P4)		Reserved	0x66	Current
0x2C(P4)	WHTPXLTH	Threshold of number of white pixel for AWB	0x0A	Current
0x2D(P4)		Reserved	0x08	Current
0x2E(P4)		Reserved	0x04	Current
0x2F(P4)		Reserved	0x88	Current
0x30(P4)		Reserved	0x50	Current
0x31(P4)		Reserved	0xA1	Current
0x32(P4)		Reserved	0xA4	Current
0x33(P4)		Reserved	0xC8	Current
0x34(P4)		Reserved	0x0A	Current
0x35(P4)		Reserved	0x08	Current
0x36(P4)		Reserved	0x43	Current
0x37(P4)		Reserved	0x44	Current
0x38(P4)		Reserved	0x44	Current
0x39(P4)		Reserved	0x44	Current
0x3A(P4)		Reserved	0x0A	Current
0x3B(P4)		Reserved	0x44	Current
0x40(P4)	RGAIN	Red color gain	0x30	Next
0x41(P4)	GGAIN	Green color gain	0x20	Next
0x42(P4)	BGAIN	Blue color gain	0x38	Next
0x43(P4)	RMAX	Maximum RGAIN in AWB	0x50	Current



0x44(P4)	RMIN	Minimum RGAIN in AWB	0x20	Current
0x45(P4)	BMAX	Maximum BGAIN in AWB	0x50	Current
0x46(P4)	BMIN	Minimum BGAIN in AWB	0x20	Current
0x47(P4)	RMAXB	Upper limit of RGAIN in outdoor condition	0x50	Current
0x48(P4)	RMINB	Lower limit of RGAIN in outdoor condition	0x3E	Current
0x49(P4)	BMAXB	Upper limit of BGAIN in outdoor condition	0x2E	Current
0x4A(P4)	BMINB	Lower limit of BGAIN in outdoor condition	0x20	Current
0x4B(P4)	REXPLMT	Threshold of exposure time to change the boundary of RGAIN	0x08	Current
0x4C(P4)	BEXPLMT	Threshold of exposure time to change the boundary of BGAIN	0x08	Current
0x4D(P4)	RDELTA	Increasing (Decreasing) step of RGAIN	0x04	Current
0x4E(P4)	BDELTA	Increasing (Decreasing) step of BGAIN	0x60	Current
0x4F(P4)	BGAINPARA1	Parameter1 of BGAIN	0x50	Current
0x50(P4)	BGAINPARA2	Parameter2 of BGAIN	0x4C	Current
0x51(P4)	BGAINPARA3	Parameter3 of BGAIN	0x48	Current
0x52(P4)	BGAINPARA4	Parameter4 of BGAIN	0x46	Current
0x53(P4)	BGAINPARA5	Parameter5 of BGAIN	0x44	Current
0x54(P4)	BGAINPARA6	Parameter6 of BGAIN	0x42	Current
0x55(P4)	BGAINPARA7	Parameter7 of BGAIN	0x40	Current
0x56(P4)	BGAINPARA8	Parameter8 of BGAIN	0x3E	Current
0x57(P4)	BGAINPARA9	Parameter9 of BGAIN	0x3C	Current
0x58(P4)	BGAINPARA10	Parameter10 of BGAIN	0x28	Current
0x59(P4)	BGAINPARA11	Parameter11 of BGAIN	0x26	Current
0x5A(P4)	BGAINPARA12	Parameter12 of BGAIN	0x24	Current
0x5B(P4)	BGAINBND1	Boundary1 of BGAIN	0x44	Current
0x5C(P4)	BGAINBND2	Boundary2 of BGAIN	0x44	Current
0x5D(P4)	RGAINTH1	Threshold1 of RGAIN	0x40	Current
0x5E(P4)	RGAINTH2	Threshold2 of RGAIN	0x30	Current
0x5F(P4)	RGAINTH3	Threshold3 of RGAIN	0x20	Current
0x60(P4)	ULVL	U chrominance level to converge in AWB	0x80	Current
0x61(P4)	VLVL	V chrominance level to converge in AWB	0x80	Current
0x62(P4)		Reserved	0x88	Current
0x63(P4)		Reserved	0x88	Current
0x64(P4)		Reserved	0x30	Current
0x65(P4)		Reserved	0x48	Current
0x66(P4)	MRGAIN	RGAIN for manual white balance	0x48	Current
0x67(P4)	MBGAIN	BGAIN for manual white balance	0x40	Current
0x80(P4)		Reserved	0x00	Current
0x81(P4)		Reserved	0x80	Current
0x82(P4)		Reserved	0x80	Current
0x83(P4)		Reserved	RO	
0x84(P4)		Reserved	RO	
0xD2(P4)	UAVG	Average of U chrominance of white pixels in frame	RO	
0xD3(P4)	VAVG	Average of V chrominance of white pixels in frame	RO	
0xD4-0xF2 (P4)		Reserved	RO	

Note) Siliconfile Technologies Inc. provides the optimum values for reserved registers.



6.1. Common Group

0x03 [common mode]: PAGEMODE [default=0x00, r/w]

Bit	Function	Description	Default
B[7:4]		Reserved	0000b
B[3:0]	Page Mode	<p><i>User should set this register before controlling registers to adjust functions. This register classified the group of function to control registers easily.</i></p> <p>0 : Image size, Windowing, V/HSync, Black level calibration function</p> <p>1 : Image effect, Image format, Color saturation, Color correction, Gamma correction, Edge enhancement, Noise Reduction, Dead pixel concealment</p> <p>2 : Image scaling, Auto flicker cancellation, Auto focus data , Lens shading correction</p> <p>3 : Auto exposure function</p> <p>4 : Auto white balance function</p>	0000b

0x01 [page mode 0]: PWRCTL [default=0x00, r/w]

Bit	Function	Description	Default
B[7:6]	PCLK Drive	It increases high drivability of PCLK pin as high value	00b
B[5:4]	Output Drive	It increases high drivability of output pin as high value (VSYNC, HSYNC and D[7:0] D_LSB0, D_LSB1)	00b
B[3:2]		Reserved	00b
B[1]	Soft Reset	Enable Software reset. When this bit is high, registers' values are initialized.	0b
B[0]	Power Sleep	Set power sleep by preserving the value of all registers. (0: OFF, 1: ON)	0b

0x02 [page mode 0]: PLLCTL1 [default=0x00, r/w]

Bit	Function	Description	Default
B[7:6]	PLL Lock Time	PLL lock time is waiting time for stable PLL operation, in case PLL is enabled or PLL mode is changed. Output clock of PLL is valid after waiting PLL lock time. PLL lock time = B[7:6] * 2048 * period of MCLK	00b
B[5:4]	PLL delay	Control the delay of output clock of PLL. 00(no delay) ~ 11(more delay)	00b
B[3]	PLL1 Enable	Enable PLL1 for Sensor Operation. 0: OFF, 1:ON	0b
B[2]	PLL2 Enable	Enable PLL2 for LVDS 0: OFF, 1:ON	0b
B[1]	LVDS En	Enable switch for LVDS circuit. This bit should be set to 1 for LVDS operation	0b
B[0]	LVDS Enb	Disable switch for LVDS circuit. This bit should be set to 0 for LVDS operation	0b

0x08 [page mode 0]: PLLCTL2 [default=0x2B, r/w]

Bit	Function	Description	Default
B[7:5]	PLL2 Mode	Select output clock of PLL2. The output clock of PLL2 is multiple of PCLK 001: 8x, 110: 10x, 010: 12x	001b
B[4:0]	PLL1 Mode	Select output clock of PLL1. The output clock of PLL1 is multiple of MCLK 1: 1x, 2: 1.5x, 3: 2x, 4: 2.5x, 5: 3x, 6: 3.5x, 7: 4x, 8: 4.5x, 9: 5x, 10: 5.5x, 11: 6x, 12: 6.5x, 13: 7x, 14: 7.5x, 15: 8x, 16: 8.5x, 17: 9x, 18: 9.5x, 19: 10x, 20: 10.5x, 21: 11x, 22: 11.5x, 23: 12x, 24: 12.5x, 25: 13x, 26: 13.5x, 27: 14x, 28: 14.5x, 29: 15x, 30: 15.5x, 31: 16x	0_1011b



0x09 [page mode 0]: PLLCTL3 [default=0x00, r/w]

Bit	Function	Description	Default
B[7:5]	VCM	Control Common mode voltage for LVDS. 001 : MIPI, 010 : SMIA	00b
B[4:3]	Current	Control the amount of current for LVDS 00 : 1.4x, 01: 1.2x, 10: 1x, 11: 0.8x	00b
B[2:0]	Voltage	Control the amount of voltage for LVDS 001 : 0.75x, 010: 1x, 101 :1.25x	0000b

0x0A [page mode 0]: PLLCTL4 [default=0x00, r/w]

Bit	Function	Description	Default
B[7:3]	PL	Reserved	
B[2:0]		Control input clock of PLL2.	000b

6.2. Device Identification

0x04 [page mode 0]: DEVID [default=0x71, r]

Bit	Function	Description	Default
B[7:0]	Device ID	Device ID to define NOON300PC51	0111_0001b

6.3. Image Size / Windowing / HSYNC / VSYNC[Type1]

0x10 [page mode 0]: VDOCTL1 [default=0x00, r/w]

Bit	Function	Description	Default
B[7:6]	Reference Image	Sub-sampling is done from reference image size. 00:2048X1536(QXGA)	00b
B[5:4]	Sub-sampling	This function reduces image output resolution by skipping the number of rows and columns, while maintaining the same view and frame rate. 00: No sub-sampling(QXGA), 01: 1/2 sub-sampling(skipping 2pixel, XGA), 10: 1/4 sub-sampling(skipping 4pixel, QSVGA), 11: Reserved	00b
B[3]	VSYNC Type	0 : HSYNC doesn't overlap with VSYNC [Type1] 1 : HSYNCs are in the VSYNC [Type2]. Refer to the timing description.	0b
B[2]		Reserved	0b
B[1]	Preview2	When this bit is selected, sensor skips two pixels every a two column. It should be used with preview1. Then frame rate of preview2 is faster than that of preview1.	0b
B[0]	Preview1	When this bit is selected, sensor skips two pixels every a two row. Frame rate of preview1 is two times faster than that of full size (0:OFF, 1:ON)	0b

(Note) Refer to 5.16 [Timing Description]

0x11 [page mode 0]: VDOCTL2 [default=0x90, r/w]

Bit	Function	Description	Default
B[7]	Windowing	User changes image size by setting WINROW[0x13,0x14:P0], WINCOL [0x15,0x16:P0], WINHGT [0x17,0x18:P0] and WINWID[0x19,0x1A:P0]. (0:OFF, 1:ON)	1b
B[6:4]	Bad Frame Skip	It is used to skip bad frames when image size is changed. 000: No Skip frame, 001: Skip 1frame. 010: Skip 2frames, 011: Skip 3frames 100: Skip 4frame, 101: Skip 5frame. 110: Skip 6frames, 111: Skip 7frames	001b
B[3]	Strobe	Strobe function Enable(0: OFF, 1: ON). Refer to STRCTL[0x30:P0] and STRWID[0x31:P0]	0b
B[2]	Fixed Frame Rate	Set frame time to be constant, regardless of the change of exposure time. (0:OFF, 1:ON) It is related to EXPFIX[0x41,0x42,0x43:P3] and EXPINC[0x44, 0x45, 0x46:P3].	0b



B[1]	Y Flip	Vertical Flip Function (0:OFF, 1:ON)	0b
B[0]	X Flip	Horizontal Flip Function (0:OFF, 1:ON)	0b

0x12 [page mode 0]: SYNCCTL [default=0x04, r/w]

Bit	Function	Description	Default
B[7:6]		Reserved	00b
B[5]	VSYNC Polarity	Select polarity of VSYNC[Type1]. 0 : When VSYNC[Type1] is high, there are no valid HSYNCs When VSYNC[Type2] is high, there are valid HSYNCs 1 : When VSYNC[Type1] is low, there are no valid HSYNCs When VSYNC[Type2] is low, there are valid HSYNCs	0b
B[4]	HSYNC Polarity	Select polarity of HSYNC. 0: Active High : When HSYNC is high, image data is valid. 1: Active Low : When HSYNC is low, image data is valid.	0b
B[3]	VSYNC Clipping	Clip VSYNC[Type1]. Refer to VSCLIP[0x1F:P0] (0:OFF, 1:ON)	0b
B[2]	Clock Inversion	Select phase of PCLK 0: D[7:0] are synchronized at rising edge of PCLK 1: D[7:0] are synchronized at falling edge of PCLK	1b
B[1:0]	Clock Divider	Divides the frequency of internal CLOCK 00:1x, 01:1/2x, 10: 1/4x. 11: 1/8x	00b

0x13 [page mode 0]: WINROWH [default=0x00, r/w]

Bit	Function	Description	Default
B[7:3]		Reserved	0000_0b
B[2:0]	Windowing	High byte of row start point for windowing WINROW[10:0]={WINROWH[2:0], WINROWL[7:0]}. Both WINROWH and WINROWL should be updated when WINROW is changed. Refer to 5.12[Windowing] for recommended setting value	000b

0x14 [page mode 0]: WINROWL [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Windowing	Low byte of row start point for windowing	0000_0000b

0x15 [page mode 0]: WINCOLH [default=0x00, r/w]

Bit	Function	Description	Default
B[7:3]		Reserved	0000_0b
B[2:0]	Windowing	High byte of column start point for windowing WINCOL[10:0]={WINCOLH[2:0], WINCOLL[7:0]} Both WINCOLH and WINCOLL should be updated when WINCOL is changed. Refer to 5.12[Windowing] for recommended setting value	000b

0x16 [page mode 0]: WINCOLL [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Windowing	Low byte of column start point for windowing	0000_0000b

0x17 [page mode 0]: WINHGTH [default=0x06, r/w]

Bit	Function	Description	Default
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B[7:3]		Reserved	0000_0b
B[2:0]	Windowing	High byte of height for windowing WINHGT[10:0]={WINHGTH[2:0], WINHGTL[7:0]}. Both WINHGTH and WINHGTL should be updated when WINHGT is changed. Refer to 5.12[Windowing] for recommended setting value	100b

0x18[page mode 0]: WINHGTL [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Windowing	Low byte of height for windowing	0000_0000b

0x19[page mode 0]: WINWIDTH [default=0x08, r/w]

Bit	Function	Description	Default
B[7:3]		Reserved	0000_0b
B[2:0]	Windowing	High byte of width for windowing WINWID[10:0]={WINWIDTH[2:0], WINWIDL[7:0]}. Both WINWIDTH and WINWIDL should be updated when WINWID is changed. Refer to 5.12[Windowing] for recommended setting value	110b

0x1A[page mode 0]: WINWIDL [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Windowing	Low byte of width for windowing	0000_0000b

0x1B[page mode 0]: HBLANKH [default=0x00, r/w]

Bit	Function	Description	Default
B[7:4]		Reserved	0000b
B[3:0]	HBLANK	High byte of horizontal blanking time. Unit of HBLANK is OPCLK's period HBLANK[11:0] = {HBLANKH[3:0], HBLANKL[7:0]} . HBLANK is interval between continuous image data lines(HSYNC). HBLANK should be greater than 196 and should be multiple of 4. Both HBLANKH and HBLANKL should be updated when HBLANK is changed. Refer to 5.13[Frame Structure] and 5.16[Timing Description] We recommend that HBLANK is set to meet following equation. 1) $(EXP100[0x3B,3C:P3] * 8 * T_{OPCLK}) / (\text{Data Width} + \text{HBLANK})$ should be integer for 100Hz flicker cancellation 2) $(EXP120[0x3D,3E:P3] * 8 * T_{OPCLK}) / (\text{Data width} + \text{HBLANK})$ should be integer for 120Hz flicker cancellation (Data Width = 820 for preview2 , Data Width =1632 elsewhere) Note) When auto-flicker cancellation(100Hz/120Hz) is enabled, HBLANK should be set to meet 1) and 2).	0000b

0x1C[page mode 0]: HBLANKL [default=0xC4, r/w]

Bit	Function	Description	Default
B[7:0]	HBLANK	Low byte of horizontal blanking time	1100_0100b

0x1D[page mode 0]: VSYNCH [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	VSYNC	High byte of duration for vertical synchronization[Type1] VSYNC is interval between continuous image frames. VSYNC[15:0] = {VSYNCH[7:0], VSYNCL[7:0]} Unit of VSYNC is one line processing time (Data Width + HBLANK).	0000_0000b



		(Data Width = 1044 for preview2 , Data Width =2080, elsewhere) Both VSYNCH and VSYNCL should be updated when VSYNC is changed. Refer to 5.13[Frame Structure] and 5.16[Timing Description] Note) VSYNC should not be set to 1.	
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0x1E[page mode 0]: VSYNCL [default=0x14, r/w]

Bit	Function	Description	Default
B[7:0]	VSYNC	Low byte of duration for vertical synchronization[Type1]	0001_0100b

0x1F[page mode 0]: VSCLIP [default=0x09, r/w]

Bit	Function	Description	Default
B[7:0]	VSYNC	VSCLIP is clipping line in VSYNC[Type1] when enabling bit[3] of SYNCTL[0x12:P0]. When the interval between last HSYNC and VSYNC[Type1] should be controlled, VSCLIP is used to adjust the interval. Unit of VSYNC is one line processing time (Data Width + HBLANK) Refer to 5.13[Frame Structure] and 5.16[Timing Description] Note) VSCLIP should be under VSYNC	0000_1001b

6.4. Black Level Calibration**0x20[page mode 0]: BLCCTL1 [default=0xA8, r/w]**

Bit	Function	Description	Default
B[7]	BLC Offset	0: calibrate plus offset in black level calibration 1: calibrate plus and minus offset in black level calibration	1b
B[6]		Reserved	0b
B[5]	BLC Enable	Enable BLC operation (0:OFF, 1:ON)	1b
B[4]		Reserved	0b
B[3]	BLC DPC	Sensor can enable dead pixel concealment in BLC pixels. (0: OFF, 1: ON)	1b
B[2]	R offset Polarity	0 : subtract red color offset[0x22:P0] to ADC output 1 : add red color offset[0x22:P0] to ADC output	0b
B[1]	G offset Polarity	0 : subtract green color offset[0x23:P0] to ADC output 1 : add green color offset[0x23:P0] to ADC output	0b
B[0]	B offset Polarity	0 : subtract blue color offset[0x24:P0] to ADC output 1 : add red color offset[0x24:P0] to ADC output	0b

0x21[page mode 0]: BLCCTL2 [default=0x00, r/w]

Bit	Function	Description	Default
B[7:2]		Reserved	0000_00b
B[1]	Dark Offset	Additional offset at dark condition on BLC (0:OFF, 1:ON). DOFSR, DOFSG, and DOFSB are used as additional offset.	0b
B[0]		Reserved	0b

0x22[page mode 0]: DOFSR [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	BLC	Red color offset is added/subtracted to output of ADC and have range from -510 to 510 codes in 10bit system. Absolute value = B[7:0] * 2	0000_0000b

0x23[page mode 0]: DOFSG [default=0x00, r/w]

Bit	Function	Description	Default
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B[7:0]	BLC	Green color offset is added/subtracted to output of ADC and have range from -510 to 510 codes in 10bit system. Absolute value = B[7:0] * 2	0000_0000b
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0x24[page mode 0]: DOFSB [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	BLC	Blue color offset is added/subtracted to output of ADC and have range from -510 to 510 codes in 10bit system. Absolute value = B[7:0] * 2	0000_0000b

0x25[page mode 0]: AOFSR [default=0x00, r/w]

Bit	Function	Description	Default
B[7]		Reserved	0b
B[6:0]	BLC	When manually controlling black level offset, Red color offset are added/subtracted to input of ADC and have range from -126 to 126 codes in 10bit system. $R' = R + AOFSR[5:0]*2$ for AOFSR[6] is 0 $= R - AOFSR[5:0]*2$ for AOFSR[6] is 1, where R is input voltage level of ADC(10bit)	000_0000b

0x26[page mode 0]: AOFSG [default=0x00, r/w]

Bit	Function	Description	Default
B[7]		Reserved	0b
B[6:0]	BLC	When manually controlling black level offset, Green color offset is added/subtracted to input of ADC and have range from -126 to 126 codes in 10bit system. $G' = G + AOFSG[5:0]*2$ for AOFSG[6] is 0 $= G - AOFSG[5:0]*2$ for AOFSG[6] is 1, where G is input voltage level of ADC(10bit)	000_0000b

0x27[page mode 0]: AOFBS [default=0x00, r/w]

Bit	Function	Description	Default
B[7]		Reserved	0b
B[6:0]	BLC	When manually controlling black level offset, Blue color offset is added/subtracted to input of ADC and have range from -126 to 126 codes in 10bit system. $B' = B + AOFBS[5:0]*2$ for AOFBS[6] is 0 $= B - AOFBS[5:0]*2$ for AOFBS[6] is 1, where B is input voltage level of ADC(10bit)	000_0000b

0x28[page mode 0]: CAOFS [default=0x20, r/w]

Bit	Function	Description	Default
B[7:6]		Reserved	00b
B[5:0]	BLC	Reference offset for black level calibration Reference offset is added to black pixels(light shielded pixels) to calculate black level offset. It has range from 0 to 126 codes in 10bit system.	10_0000b

0x2E[page mode 0]: BLCCTL3 [default=0x00, r/w]

Bit	Function	Description	Default
B[7]	BLC	0: Use single frame to get black level 1: Use multiple frames to get black level	0b
B[6:4]		The threshold to define whether change of image is steady or not	000b
B[3]		Reserved	0b
B[2]		When image is changed abruptly, number of frames is used to calculate black level. 0:1frame, 1: 2frame	0b
B[1:0]		When image is steady, number of frames is used to calculate black level. 0 :1frame, 1 : 2frame, 2 : 4frame, 3 : 8frame	00b



6.5. Strobe

0x30[page mode 0]: STRCTL[default=0x09, r/w]

Bit	Function	Description	Default
B[7]	Strobe	Single XENON strobe pulse is generated, when this bit is enabled. (0:OFF, 1:ON)	0b
B[6]		Adaptive LED Strobe (0:OFF, 1:ON) When this bit is enabled, strobe pin is active according to exposure time. Because exposure time is changed by light environment, strobe pin goes to high at dark side and goes to low at bright side. 1) Exposure time > bit[7:4] * STRTIME[0x32:P0] * 1/100sec(1/120sec), Strobe pin is high. 2) Exposure time < bit[3:0] * STRTIME[0x32:P0] * 1/100sec(1/120sec), Strobe pin is low.	0b
B[5]		Continuous LED strobe (0:OFF, 1:ON) When this bit is enabled, strobe pin is always high regardless of exposure time.	0b
B[4]		Continuous XENON strobe (0:OFF, 1:ON) When this bit is enabled and exposure time is over the frame time, there is a period that all pixels are exposed at the same time. Strobe pin goes to high in a moment.	0b
B[3]		When XENON(bit[7] or bit[4]) is selected, sensor controls the width of strobe pulse. 0 : Constant pulse width of XENON strobe 1: Programmable pulse width of XENON strobe(Refer to STRWID[0x31:P0])	1b
B[2]		Polarity of strobe. 0: High active, 1: Low active	0b
B[1]		When this bit is enabled, MRGAIN[0x66:P4] and MBGAIN[0x67:P4] are used for white balance	0b
B[0]		When this bit is enabled, XENON strobe pulse is generated in active VSYNC (0:OFF, 1:ON)	1b

0x31[page mode 0]: STRWID[default=0x0C, r/w]

Bit	Function	Description	Default
B[7:0]	Strobe	Strobe Pulse Width = b[7:0] * 128 * OPCLK. It is used in XENON strobe.	0000_1100b

0x32[page mode 0]: STRTIME[default=0x43, r/w]

Bit	Function	Description	Default
B[7:4]	Strobe	Strobe time high threshold = bit[7:4] * 4/100sec(4/120sec) It is threshold to enable adaptive LED strobe pulse.	0100b
B[3:0]		Strobe time low threshold = bit[3:0] * 4/100sec(4/120sec) It is threshold to disable adaptive LED strobe pulse.	0011b



6.6. VSYNC[Type2]

0xA1[page mode 0]: VSCTL1 [default=0x04, r/w]

Bit	Function	Description	Default
B[7:4]	VSYNC	High 4bits of start row position for vertical synchronization(Type2)	0000b
B[3:0]	VSYNC	High 4bits of stop row position for vertical synchronization(Type2)	0100b

0xA2[page mode 0]: VSCTL2 [default=0x04, r/w]

Bit	Function	Description	Default
B[7:0]	VSYNC [Type2]	Low byte of start row position for vertical synchronization(Type2) Vertical start row position = VSCTL1[7:4]*256 + VSCTL2[7:0] Unit of Vertical start(stop) row position is one line processing time (Data Width + HBLANK). (Data Width = 1044 for preview2 , Data Width =2048 elsewhere) VSYNC[Type2] duration = Vertical stop row position - Vertical start row position Refer to 5.13[Frame Structure] and 5.16[Timing Description] Note) Vertical start row position should not be under 4.	0000_0100b

0xA3[page mode 0]: VSCTL3 [default=0xB4, r/w]

Bit	Function	Description	Default
B[7:0]	VSYNC [Type2]	Low byte of stop row position for vertical synchronization(Type2) Vertical stop row position = VSCTL1[3:0]*256 + VSCTL3[7:0] Note) When preview1 or preview2 mode is used, vertical stop row position should be changed.	1011_0100b



6.7. Image Output Format and Image Effect

0x10[page mode 1]: ISPCTL1[default=0x03, r/w]

Bit	Function	Description	Default
B[7:4]	Data Format	0000: YUV4:2:2 8bit, 0100: RGB5:6:5 8bit, 0111: RGB4:4:4	0000b
B[3]		Reserved	0b
B[2]	ITU656	ITU656-like(0:OFF, 1:ON)	0b
B[1]	Y Phase	Select U/V(R/B) and Y(G) phase for output data. 0: UYVY for U Phase is ON, VYUY.... for U Phase is OFF 1: YUYV for U Phase is ON, YVYU.... for U Phase is OFF	1b
B[0]	U Phase	Select U(B) and V(R) phase for output data. 0: VYUY... for Y Phase is OFF, YVYU.... for Y Phase is ON 1: UYVY... for Y Phase is OFF, YUYV.... for Y Phase is ON	1b

0x11[page mode 1]: ISPCTL2[default=0x03, r/w]

Bit	Function	Description	Default
B[7:6]		Reserved	00b
B[5]	Embossing	Embossing Effect (0:OFF, 1:ON)	0b
B[4]	Sketch	Sketch Effect (0:OFF, 1:ON)	0b
B[3]	Solarization1	Solarization Effect1 is controlled by adjusting SOLARI[0x1F:P1]. (0:OFF, 1:ON)	0b
B[2]	Solarization2	Solarization Effect2 is controlled by adjusting SOLARI[0x1F:P1]. (0:OFF, 1:ON)	0b
B[1]	Color Space Conversion	Color space conversion is done by enabling this bit. (0:OFF, 1:ON) RGB => YUV (Refer to 5.6[Color Space Conversion])	1b
B[0]	Color Interpolation	Because the raw data of the pixel array has only one of R, G or B for each pixel, sensor should perform color interpolation to recover the missing color component for each pixel. Color interpolation is done, by enabling this bit. (0:OFF, 1:ON)	1b

0x12[page mode 1]: ISPCTL3[default=0x00, r/w]

Bit	Function	Description	Default
B[7]	V OFFSET	Control V by adding or subtracting VOFS[0x1C:P1]. (0:OFF, 1:ON)	0b
B[6]	U OFFSET	Control U by adding or subtracting UOFS[0x1B:P1]. (0:OFF, 1:ON)	0b
B[5]	AUTO BRIGHT	Control Y by adding DYOFs[0x1A:P1] at dark environment. (0:OFF, 1:ON)	0b
B[4]	Y OFFSET	Control Y by adding or subtracting YOFS[0x19:P1]. (0:OFF, 1:ON)	0b
B[3]	Negative	Enable Negative effect	0b
B[2]	Color Inversion	$U' = V, V' = U$ (0:OFF, 1:ON)	0b
B[1]	V Constant	This bit makes the output of V constant. User can get mono, sepia and other special image by setting UCON[0x1D:P1] and VCON[0x1E:P1]. (0:OFF, 1:ON)	0b
B[0]	U Constant	This bit makes the output of U constant. User can get mono, sepia and other special image by setting UCON[0x1D:P1] and VCON[0x1E:P1]. (0:OFF, 1:ON)	0b

0x13[page mode 1]: ISPCTL4[default=0x00, r/w]

Bit	Function	Description	Default
B[7:5]		Reserved	000b
B[4]	Negative Option	When Negative Effect is enabled, user can select effect1 or effect2. 0: Negative Effect1, 1: Negative Effect2	0b
B[3]		Reserved	0b
B[2]	Solarization3	Solarization Effect3 is controlled by adjusting SOLARITH[0x25:P1]. (0:OFF, 1:ON)	0b



B[1]	Contrast Effect	Enable Contrast Effect. (0:OFF, 1:ON) User can control contrast effect by adjusting CONTRAST[0x24:P1].	0b
B[0]	Binary Effect	Enable Binary Effect. (0:OFF, 1:ON) User can control binary effect by adjusting BINARY[0x23:P1].	0b

0x14[page mode 1]: ISPCTL5[default=0x00, r/w]

Bit	Function	Description	Default
B[7:3]		Reserved	00000b
B[2]	Range	Select range of YUV output data. 0= Y: 0 ~255, U: 0~255, V: 0~255, 1= Y: 16 ~235, U: 16~240, V: 16~240	0b
B[1]	Cut Bound	Y : 0 ~ 255, U: 0 ~ 255, V: 0 ~ 255 at OFF Y : 1 ~ 254, U: 1 ~ 254, V: 1 ~ 254 at ON	0b
B[0]	SOF EOF	When this bit is enabled at ITU656 mode, data(D[7:0]) has special codeword to represent start of line and end of line and start of frame and end of frame. (0:OFF, 1:ON)	0b

0x19[page mode 1]: YOFS [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Brightness	Luminance offset(Brightness function) is controlled by the following equation and bit[4] of ISPCTL3[0x12:P1]. $Y' = Y + YOFS[6:0],$ for YOFS[7] = 0 $= Y - YOFS[6:0],$ for YOFS[7] = 1	0000_0000b

0x1A[page mode 1]: DYOFS [default=0x00, r/w]

Bit	Function	Description	Default
B[7:6]		Reserved	00b
B[5:0]	Auto Brightness	Luminance offset coefficient at dark condition. When AG[0x50:P3] is greater than AGBRT[0x58:P3] at dark environment by auto exposure control, sensor controls luminance by following equation $Y' = Y + DYOFS[5:0]$ for AG > AGBRT $= Y$ elsewhere	00_0000b

0x1B[page mode 1]: UOFS [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	U offset	U chrominance offset coefficient. U chrominance offset is controlled by the following equation and bit[6] of ISPCTL3[0x12:P1]. $U' = U + UOFS[6:0],$ for UOFS[7] = 0 $= U - UOFS[6:0],$ for UOFS[7] = 1	0000_0000b

0x1C[page mode 1]: VOFS [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	V offset	V chrominance offset coefficient. V chrominance offset is controlled by the following equation and bit[7] of ISPCTL3[0x12:P1]. $V' = V + VOFS[6:0],$ for VOFS[7] = 0 $= V - VOFS[6:0],$ for VOFS[7] = 1	0000_0000b

0x1D[page mode 1]: UCON [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Chrominance Constant	UCON makes the output of U constant and VCON makes the output of V constant. User can get mono, sepia and other special image by controlling these values and bit[1:0] of ISPCTL3[0x12:P1].	1000_0000b



	Example) Mono: UCON=0x80 and VCON=0x80	
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0x1E[page mode 1]: VCON [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Chrominance Constant	UCON makes the output of U constant and VCON makes the output of V constant. User can get mono, sepia and other special image by controlling these values and bit[1:0] of ISPCTL3[0x12:P1]. Example) Mono: UCON=0x80 and VCON=0x80	1000_0000b

0x1F[page mode 1]: SOLARI [default=0xF0, r/w]

Bit	Function	Description	Default
B[7:0]	Solarization Effect1/2	Solarization effect1. 0x00(more solarization) ~ 0xFF(normal image) Solarization effect2. 0x00(normal image) ~ 0xFF(more solarization)	1111_0000b

6.8. Color Saturation

0x20[page mode 1]: SATCTL[default=0x00, r/w]

Bit	Function	Description	Default
B[7:4]		Reserved	0000b
B[3:2]	Suppression Ratio	Suppression ratio in auto color saturation. 00 ~ 11(more suppression)	00b
B[1]	Auto Color Saturation	Enable auto color saturation. As AG[0x50:P3] is increased, the more color noise is occurred in image. To suppress the color noise, color saturation is decreased as AG (0:OFF, 1:ON)	0b
B[0]	Manual Color Saturation	When this bit is enabled, SATB[0x21:P1] and SATR[0x22:P2] are multiplied to U and V. (0:OFF, 1:ON)	0b

0x21[page mode 1]: SATB [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Saturation B Gain	Blue color saturation coefficient. SATB is gain of color difference signal U. It is enabled by bit[0] of SATCTL[0x20:P1]. 0x00 ~ 0xFF(more U color saturation)	1000_0000b

0x22[page mode 1]: SATR [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Saturation R Gain	Red color saturation coefficient. SATR is gain of color difference signal V. It is enabled by bit[0] of SATCTL [0x20:P1]. 0x00 ~ 0xFF(more V color saturation)	1000_0000b

0x23[page mode 1]: BINARY [default=0x7F, r/w]

Bit	Function	Description	Default
B[7:0]	Binary Effect	Threshold of Binary Effect. When luminance value is over the this value, output is 0x80. When luminance value is not over this value, output is 0.	0111_1111b

0x24[page mode 1]: CONTRAST [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Contrast Effect	Parameter for Contrast Effect. Programmable range is from 0x80 (1x) to from 0xff(1.99x)	1000_0000b



0x25[page mode 1]:SOLARITH[default=0x7F, r/w]

Bit	Function	Description	Default
B[7:0]	Solarization Effect3	Threshold for Solarization Effect3	0111_1111b

6.9. Color Correction

0x30[page mode 1]: CMCCTL[default=0x0F, r/w]

Bit	Function	Description	Default
B[7:4]		Reserved	0000b
B[3]	CMC1x double	0 : The range of CMC11, CMC12, CMC13 = -1.99 ~ 1.99 1 : The range of CMC11, CMC12, CMC13 = -3.99 ~ 3.99	1b
B[2]	CMC2x double	0 : The range of CMC21, CMC22, CMC23 = -1.99 ~ 1.99 1 : The range of CMC21, CMC22, CMC23 = -3.99 ~ 3.99	1b
B[1]	CMC3x double	0 : The range of CMC31, CMC32, CMC33 = -1.99 ~ 1.99 1 : The range of CMC31, CMC32, CMC33 = -3.99 ~ 3.99	1b
B[0]	CMC ON	Enable color correction (0:OFF, 1:ON)	1b

0x33[page mode 1]: CMCOFSGH [default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	High threshold of color offset gain	0100_0000b

0x34[page mode 1]: CMCOFSGM [default=0x30, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Middle threshold of color offset gain	0011_0000b

0x35[page mode 1]: CMCOFSSL [default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Low threshold of color offset gain	0010_0000b

0x36[page mode 1]: CMCSIGN [default=0x2F, r/w]

Bit	Function	Description	Default
B[7:6]	Color Correction	Reserved	00b
B[5]		Sign of CMC12, 0: +, 1: -	1b
B[4]		Sign of CMC13, 0: +, 1: -	0b
B[3]		Sign of CMC21, 0: +, 1: -	1b
B[2]		Sign of CMC23, 0: +, 1: -	1b
B[1]		Sign of CMC31, 0: +, 1: -	1b
B[0]		Sign of CMC32, 0: +, 1: -	1b

Note) Sign of CMC11 and CMC22 and CMC33 is always +(positive)

0x38[page mode 1]: CMC11 [default=0x4C, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Color correction coefficient11. 0x00(0) ~ 0xFF(1.99) for bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(3.99) for bit[3] of CMCCTL[0x30:P1] = 1	0100_1100b



0x39[page mode 1]: CMC12 [default=0x0C, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Color correction coefficient12. Bit[5] of CMC_SIGN[0x36:P1] = 0 and bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(1.99), Bit[5] of CMC_SIGN[0x36:P1] = 1 and bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(-1.99), Bit[5] of CMC_SIGN[0x36:P1] = 0 and bit[3] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(3.99), Bit[5] of CMC_SIGN[0x36:P1] = 1 and bit[3] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(-3.99)	0000_1100b

0x3A[page mode 1]: CMC13 [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Color correction coefficient13. Bit[4] of CMC_SIGN[0x36:P1] = 0 and bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(1.99), Bit[4] of CMC_SIGN[0x36:P1] = 1 and bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(-1.99), Bit[4] of CMC_SIGN[0x36:P1] = 0 and bit[3] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(3.99), Bit[4] of CMC_SIGN[0x36:P1] = 1 and bit[3] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(-3.99)	0000_0000b

0x3B[page mode 1]: CMC21 [default=0x26, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Color correction coefficient21 Bit[3] of CMC_SIGN[0x36:P1] = 0 and bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(1.99), Bit[3] of CMC_SIGN[0x36:P1] = 1 and bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(-1.99), Bit[3] of CMC_SIGN[0x36:P1] = 0 and bit[2] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(3.99), Bit[3] of CMC_SIGN[0x36:P1] = 1 and bit[2] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(-3.99)	0010_0110b

0x3C[page mode 1]: CMC22 [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Color correction coefficient22. 0x00(0) ~ 0xFF(1.99) for bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(3.99) for bit[2] of CMCCTL[0x30:P1] = 1	1000_0000b

0x3D[page mode 1]: CMC23 [default=0x1A, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Color correction coefficient23. Bit[2] of CMC_SIGN[0x36:P1] = 0 and bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(1.99), Bit[2] of CMC_SIGN[0x36:P1] = 1 and bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(-1.99), Bit[2] of CMC_SIGN[0x36:P1] = 0 and bit[2] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(3.99),	0001_1010b



		Bit[2] of CMC_SIGN[0x36:P1] = 1 and bit[2] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(-3.99)	
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0x3E[page mode 1]: CMC31 [default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Color correction coefficient31. Bit[1] of CMC_SIGN[0x36:P1] = 0 and bit[1] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(1.99), Bit[1] of CMC_SIGN[0x36:P1] = 1 and bit[1] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(-1.99), Bit[1] of CMC_SIGN[0x36:P1] = 0 and bit[1] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(3.99), Bit[1] of CMC_SIGN[0x36:P1] = 1 and bit[1] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(-3.99)	0010_0000b

0x3F[page mode 1]: CMC32 [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Color correction coefficient32. Bit[0] of CMC_SIGN[0x36:P1] = 0 and bit[1] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(1.99), Bit[0] of CMC_SIGN[0x36:P1] = 1 and bit[1] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(-1.99), Bit[0] of CMC_SIGN[0x36:P1] = 0 and bit[1] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(3.99), Bit[0] of CMC_SIGN[0x36:P1] = 1 and bit[1] of CMCCTL[0x30:P1] = 1 0x00(0) ~ 0xFF(-3.99)	1000_0000b

0x40[page mode 1]: CMC33 [default=0xE0, r/w]

Bit	Function	Description	Default
B[7:0]	Color Correction	Color correction coefficient33. 0x00(0) ~ 0xFF(1.99) for bit[0] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0xFF(3.99) for bit[0] of CMCCTL[0x30:P1] = 1	1110_0000b

0x41[page mode 1]: CMCOFSL11 [default=0x12, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSL11, 0: +, 1: -	0b
B[6:0]		It is color offset coefficient of CMC11 for low color temperature. Absolute value of CMCOFSL11. 0x00(0) ~ 0x7F(0.1245) for bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[3] of CMCCTL[0x30:P1] = 1	001_0010b

0x42[page mode 1]: CMCOFSL12 [default=0xA0, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSL12, 0: +, 1: -	1b
B[6:0]		It is color offset coefficient of CMC12 for low color temperature. Absolute value of CMCOFSL12. 0x00(0) ~ 0x7F(0.1245) for bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[3] of CMCCTL[0x30:P1] = 1	010_0000b

0x43[page mode 1]: CMCOFSL13 [default=0x0E, r/w]

Bit	Function	Description	Default
B[7]	Color	Sign of CMCOFSL13, 0: +, 1: -	0b



B[6:0]	Correction	It is color offset coefficient of CMC13 for low color temperature. Absolute value of CMCOFSL13. 0x00(0) ~ 0x7F(0.1245) for bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[3] of CMCCTL[0x30:P1] = 1	000_1110b
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0x44[page mode 1]: CMCOFSL21 [default=0x84, r/w]

Bit	Function	Description	Default
B[7]		Sign of CMCOFSL21, 0: + , 1: -	1b
B[6:0]	Color Correction	It is color offset coefficient of CMC21 for low color temperature. Absolute value of CMCOFSL21. 0x00(0) ~ 0x7F(0.1245) for bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[2] of CMCCTL[0x30:P1] = 1	000_0100b

0x45[page mode 1]: CMCOFSL22 [default=0x08, r/w]

Bit	Function	Description	Default
B[7]		Sign of CMCOFSL22, 0: + , 1: -	0b
B[6:0]	Color Correction	It is color offset coefficient of CMC22 for low color temperature. Absolute value of CMCOFSL22. 0x00(0) ~ 0x7F(0.1245) for bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[2] of CMCCTL[0x30:P1] = 1	000_1000b

0x46[page mode 1]: CMCOFSL23 [default=0x84, r/w]

Bit	Function	Description	Default
B[7]		Sign of CMCOFSL23, 0: + , 1: -	1b
B[6:0]	Color Correction	It is color offset coefficient of CMC23 for low color temperature. Absolute value of CMCOFSL23. 0x00(0) ~ 0x7F(0.1245) for bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[2] of CMCCTL[0x30:P1] = 1	000_0100b

0x47[page mode 1]: CMCOFSL31 [default=0x8A, r/w]

Bit	Function	Description	Default
B[7]		Sign of CMCOFSL31, 0: + , 1: -	1b
B[6:0]	Color Correction	It is color offset coefficient of CMC31 for low color temperature. Absolute value of CMCOFSL31. 0x00(0) ~ 0x7F(0.1245) for bit[1] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[1] of CMCCTL[0x30:P1] = 1	000_1010b

0x48[page mode 1]: CMCOFSL32 [default=0x02, r/w]

Bit	Function	Description	Default
B[7]		Sign of CMCOFSL32, 0: + , 1: -	0b
B[6:0]	Color Correction	It is color offset coefficient of CMC32 for low color temperature. Absolute value of CMCOFSL32. 0x00(0) ~ 0x7F(0.1245) for bit[1] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[1] of CMCCTL[0x30:P1] = 1	000_0010b

0x49[page mode 1]: CMCOFSL33 [default=0x08, r/w]

Bit	Function	Description	Default
B[7]		Sign of CMCOFSL33, 0: + , 1: -	0b
B[6:0]	Color Correction	It is color offset coefficient of CMC33 for low color temperature. Absolute value of CMCOFSL33. 0x00(0) ~ 0x7F(0.1245) for bit[1] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[1] of CMCCTL[0x30:P1] = 1	000_1000b



0x4A[page mode 1]: CMCOFSH11 [default=0x12, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSH11, 0: +, 1: -	0b
B[6:0]		It is color offset coefficient of CMC11 for high color temperature. Absolute value of CMCOFSH11. 0x00(0) ~ 0x7F(0.1245) for bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[3] of CMCCTL[0x30:P1] = 1	001_0010b

0x4B[page mode 1]: CMCOFSH12 [default=0xA0, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSH12, 0: +, 1: -	1b
B[6:0]		It is color offset coefficient of CMC12 for high color temperature. Absolute value of CMCOFSH12. 0x00(0) ~ 0x7F(0.1245) for bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[3] of CMCCTL[0x30:P1] = 1	010_0000b

0x4C[page mode 1]: CMCOFSH13 [default=0x0E, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSH13, 0: +, 1: -	0b
B[6:0]		It is color offset coefficient of CMC13 for high color temperature. Absolute value of CMCOFSH13. 0x00(0) ~ 0x7F(0.1245) for bit[3] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[3] of CMCCTL[0x30:P1] = 1	000_1110b

0x4D[page mode 1]: CMCOFSH21 [default=0x84, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSH21, 0: +, 1: -	1b
B[6:0]		It is color offset coefficient of CMC21 for high color temperature. Absolute value of CMCOFSH21. 0x00(0) ~ 0x7F(0.1245) for bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[2] of CMCCTL[0x30:P1] = 1	000_0100b

0x4E[page mode 1]: CMCOFSH22 [default=0x08, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSH22, 0: +, 1: -	0b
B[6:0]		It is color offset coefficient of CMC22 for high color temperature. Absolute value of CMCOFSH22. 0x00(0) ~ 0x7F(0.1245) for bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[2] of CMCCTL[0x30:P1] = 1	000_1000b

0x4F[page mode 1]: CMCOFSH23 [default=0x84, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSH23, 0: +, 1: -	1b
B[6:0]		It is color offset coefficient of CMC23 for high color temperature. Absolute value of CMCOFSH23. 0x00(0) ~ 0x7F(0.1245) for bit[2] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[2] of CMCCTL[0x30:P1] = 1	000_0100b



0x50[page mode 1]: CMCOFSH31 [default=0x8A, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSH31, 0: + , 1: -	1b
B[6:0]		It is color offset coefficient of CMC31 for high color temperature. Absolute value of CMCOFSH31. 0x00(0) ~ 0x7F(0.1245) for bit[1] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[1] of CMCCTL[0x30:P1] = 1	000_1010b

0x51[page mode 1]: CMCOFSH32 [default=0x02, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSH32, 0: + , 1: -	0b
B[6:0]		It is color offset coefficient of CMC32 for high color temperature. Absolute value of CMCOFSH32. 0x00(0) ~ 0x7F(0.1245) for bit[1] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[1] of CMCCTL[0x30:P1] = 1	000_0010b

0x52[page mode 1]: CMCOFSH33 [default=0x08, r/w]

Bit	Function	Description	Default
B[7]	Color Correction	Sign of CMCOFSH33, 0: + , 1: -	0b
B[6:0]		It is color offset coefficient of CMC33 for high color temperature. Absolute value of CMCOFSH33. 0x00(0) ~ 0x7F(0.1245) for bit[1] of CMCCTL[0x30:P1] = 0 0x00(0) ~ 0x7F(0.2490) for bit[1] of CMCCTL[0x30:P1] = 1	000_1000b

6.10. Gamma Correction

0x60[page mode 1]: GMACTL [default=0x01, r/w]

Bit	Function	Description	Default
B[7:1]	Gamma Correction	Reserved	0000_000b
B[0]		Enable Gamma Correction	1b

0x61[page mode 1]: GMA0 [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 0(0)code in 10(8)bit linear input	0000_0000b

0x62[page mode 1]: GMA1 [default=0x15, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 16(4)code in 10(8)bit linear input	0001_0101b

0x63[page mode 1]: GMA2 [default=0x1F, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 32(8)code in 10(8)bit linear input	0001_1111b

0x64[page mode 1]: GMA3 [default=0x30, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 64(16)code in 10(8)bit linear input	0011_0000b

0x65[page mode 1]: GMA4 [default=0x49, r/w]

Bit	Function	Description	Default



B[7:0]	Gamma Correction	Gamma corrected output at 128(32)code in 10(8)bit linear input	0100_1001b
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0x66[page mode 1]: GMA5 [default=0x5D, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 192(48)code in 10(8)bit linear input	0101_1101b

0x67[page mode 1]: GMA6 [default=0x6F, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 256(64) 10(8)bit linear input	0110_1111b

0x68[page mode 1]: GMA7 [default=0x7F, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected B output at 320(80)code in 10(8)bit linear input	0111_1111b

0x69[page mode 1]: GMA8 [default=0x8E, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 384(96)code in 10(8)bit linear input	1000_1110b

0x6A[page mode 1]: GMA9 [default=0x9B, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 448(112)code in 10(8)bit linear input	1001_1011b

0x6B[page mode 1]: GMA10 [default=0xA8, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 512(128)code in 10(8)bit linear input	1010_1000b

0x6C[page mode 1]: GMA11 [default=0xB5, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 576(144)code in 10(8)bit linear input	1011_0101b

0x6D[page mode 1]: GMA12 [default=0xC1, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 640(160)code in 10(8)bit linear input	1100_0001b

0x6E[page mode 1]: GMA13 [default=0xCC, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 704(176)code in 10(8)bit linear input	1100_1100b

0x6F[page mode 1]: GMA14 [default=0xD7, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 768(192)code in 10(8)bit linear input	1101_0111b

0x70[page mode 1]: GMA15 [default=0xE2, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 832(208)code in 10(8)bit linear input	1110_0010b

0x71[page mode 1]: GMA16 [default=0xEC, r/w]

Bit	Function	Description	Default
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B[7:0]	Gamma Correction	Gamma corrected output at 896(224)code in 10(8)bit linear input	1110_1100b
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0x72[page mode 1]: GMA17 [default=0xF6, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 960(240)code in 10(8)bit linear input	1111_0110b

0x73[page mode 1]: GMA18 [default=0xFF, r/w]

Bit	Function	Description	Default
B[7:0]	Gamma Correction	Gamma corrected output at 1023(255)code in 10(8)bit linear input	1111_1111b

6.11. Edge Enhancement

0x90[page mode 1]: EDGECTL1[default=0x00, r/w]

Bit	Function	Description	Default
B[7]	Edge Enhancement	Enable edge enhancement (0:OFF, 1:ON)	0b
B[6]		Reserved	0b
B[5:3]		The parameter to decrease the edge gain as exposure time is over the EDGEEXPTH and is increased. 0: 0x, 1:1/8x, 2:1/4x, 3:1/2x, 4: 1x, 5: 2x, 6: 4x, 7:8x	00_0b
B[2:0]		The parameter to decrease the edge gain as AG is over the EDGEAGTH and is increased. 0: 0x, 1:1/8x, 2:1/4x, 3:1/2x, 4: 1x, 5: 2x, 6: 4x, 7:8x	000b

0x91[page mode 1]: EDGECTL2[default=0x9D, r/w]

Bit	Function	Description	Default
B[7:6]	Edge Enhancement	Select Filter size to find edge component	10b
B[5:3]		The ratio of decreasing edge value as AG and exposure time 0: 0x, 1:1/16x, 2:1/8x, 3:1/4x, 4: 1/2x, 5: 1x, 6: 2x, 7:4x	011b
B[2]		0 : Edge gain of high edge value is same as that of low edge value. 1 : Edge gain of high edge value is different as that of low edge value. It is controlled by bit[1:0].	1b
B[1:0]		Control the edge gain at high edge value 00 : Edge gain of high edge value = Edge gain of low edge value / 2 01 : Edge gain of high edge value = Edge gain of low edge value / 4 10 : Edge gain of high edge value = Edge gain of low edge value / 8 11 : Edge gain of high edge value = 0	01b

0x92[page mode 1]: EDGECTL3[default=0x00, r/w]

Bit	Function	Description	Default
B[7:4]	Edge Enhancement	Threshold to clip low edge value.	0000b
B[3:2]		Method to calculate edge value from edge component	00b
B[1:0]		Filter type to find edge component.	00b

0x93[page mode 1]: EDGEGAIN[default=0x42, r/w]

Bit	Function	Description	Default
B[7:4]	Edge	Negative edge gain to emphasize edge data at low edge value. 0 ~ 15(more sharp)	0100b
B[3:0]	Enhancement	Positive edge gain to emphasize edge data at low edge value. 0 ~ 15(more sharp)	0010b

0x94[page mode 1]: EGDEVALTH[default=0x10, r/w]

Bit	Function	Description	Default
B[7:0]	Edge	Threshold to define high edge value. 0 ~ 255(less sharp)	0001_0000b



	Enhancement	When edge value is over this value, edge gain of high edge value is changed.	
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0x95[page mode 1]: EGDEWEIGHT1[default=0x88, r/w]

Bit	Function	Description	Default
B[7:4]	Edge	Weight of emphasizing vertical edge component, 00(less weight) ~ 11(more weight)	1000b
B[3:0]	Enhancement	Weight of emphasizing horizontal edge component, 00(less weight) ~ 11(more weight)	1000b

0x96[page mode 1]: EGDEWEIGHT2[default=0x55, r/w]

Bit	Function	Description	Default
B[7:6]	Edge	Weight of 2 nd differential in vertical direction, 00(less weight) ~ 11(more weight)	01b
B[5:4]		Weight of 2 nd differential in horizontal direction, 00(less weight) ~ 11(more weight)	01b
B[3:2]	Enhancement	Weight of 1 st differential in vertical direction, 00(less weight) ~ 11(more weight)	01b
B[1:0]		Weight of 1 st differential in horizontal direction, 00(less weight) ~ 11(more weight)	01b

0x97[page mode 1]: EGDECOMPTH [default=0x0A, r/w]

Bit	Function	Description	Default
B[7:1]	Edge Enhancement	It is used to clip low edge component before clipping low edge value by bit[7:4] of EDGECTL3[0x92]	0000_101b
B[0]		Reserved	0b

0x99[page mode 1]: EDGEEXPTH [default=0x10]

Bit	Function	Description	Default
B[7:0]	Edge Enhancement	Threshold of exposure time for edge enhancement Time unit is 1/100(120)sec As exposure time is increased and over this register, edge value(gain) is decreased to reduce noise automatically.	0001_0000b

0x9A[page mode 1]: EDGEAGTH [default=0x10]

Bit	Function	Description	Default
B[7:0]	Edge Enhancement	Threshold of AG for edge enhancement As AG is increased and over this register, edge value(gain) is decreased to reduce noise automatically.	0001_0000b

6.12. Noise Reduction

0xA0[page mode 1]: LPFCTL1[default=0x00, r/w]

Bit	Function	Description	Default
B[7]	Noise Reduction	When exposure time is under bit[7:4] of BRTTIEMTH1[0x48:P3], D-LPF is disabled. (0:OFF, 1:ON)	0b
B[6]		Calculate automatic LPF threshold for D-LPF and Z-LPF(0:OFF, 1:ON)	0b
B[5]		Reserved.	0b
B[4]		Enable filtering method2 for D-LPF (0:OFF, 1:ON)	0b
B[3]		Enable filtering method1 for D-LPF (0:OFF, 1:ON)	0b
B[2]		Reserved	0b
B[1]		Enable D-LPF at all condition regardless of AG (0:OFF, 1:ON). B[0] is also enabled for this function.	0b
B[0]		Enable D-LPF function(0:OFF, 1:ON).	0b

0xA2[page mode 1]: LPFCTL2[default=0x08, r/w]



Bit	Function	Description	Default
B[7]	Noise Reduction	When exposure time is under bit[7:4] of BRTTIEMTH1[0x48:P3], Z-LPF is disabled. (0:OFF, 1:ON)	0b
B[6]		Use automatic LPF threshold for Z-LPF (0:OFF, 1:ON)	0b
B[5]		Ratio of automatic LPF threshold for Z-LPF. 00 : 1x, 01: 1/2x, 10: 1/4x, 11: 1/8x	00b
B[4]			
B[3]		When Z-LPF is enabled, this bit should be enabled. (0:OFF, 1:ON)	1b
B[2]		When AG is over the AGDPC, I-LPF is enabled	0b
B[1]		Enable I-LPF at all condition(0:OFF, 1:ON).	0b
B[0]		Enable Z-LPF (0:OFF, 1:ON).	0b

0xA3[page mode 1]: ZLPFCTL[default=0x08, r/w]

Bit	Function	Description	Default
B[7]	Noise Reduction	Reserved	0b
B[6]		Filter Type for Z-LPF	10b
B[5]			
B[4]		Reserved	1b
B[3]		Enable filtering method2 at green color for Z-LPF (0:OFF, 1:ON)	1b
B[2]		Enable filtering method1 at green color for Z-LPF (0:OFF, 1:ON)	0b
B[1]		Enable filtering method2 at red/blue color for Z-LPF (0:OFF, 1:ON)	0b
B[0]		Enable filtering method1 at red/blue color for Z-LPF (0:OFF, 1:ON)	0b

0xA4[page mode 1]: LPFCTL3[default=0xC0, r/w]

Bit	Function	Description	Default
B[7:6]	Noise Reduction	Reserved	00b
B[5:4]		Ratio of automatic LPF threshold as AG. 0: 1/2x, 1:1/4x, 2:1/8x, 3:1/16x	00b
B[3:2]		Ratio of automatic LPF threshold as exposure time. 0: 1x, 1:1/2x, 2:1/4x, 3:1/8x	00b
B[1:0]		Ratio of automatic LPF threshold as RGAIN 0: 1x, 1:1/2x, 2:1/4x, 3:1/8x	00b

0xA5[page mode 1]: LPFAGTH [default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	Z-LPF	Threshold of AG to reinforce LPF. When AG is increased and over the LPFAGTH, automatic LPF threshold is increased.	0010_0000b

0xA6[page mode 1]: LPFEXPTH [default=0x10, r/w]

Bit	Function	Description	Default
B[7:0]	Z-LPF	Threshold of exposure time to reinforce LPF. When exposure time is increased and over the LPFEXPTH, automatic LPF threshold is increased.	0001_0000b

0xA7[page mode 1]: LPFRGAINTH [default=0x50, r/w]

Bit	Function	Description	Default
B[7:0]	Z-LPF	Threshold of RGAIN to reinforce LPF. When RGAIN is decreased and under the LPFRGAINTH, automatic LPF threshold is increased.	0101_0000b

**0xAA**[page mode 1]: DDIFTH1 [default=0x08, r/w]

Bit	Function	Description	Default
B[7:0]	D-LPF	Threshold of the difference between center pixel and surround pixels. When difference is under DDIFTH1, D-LPF is valid.	0000_1000b

0xAD[page mode 1]: DAGON [default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	D-LPF	Threshold of AG to enable D-LPF. When AG is over the DAGON, D-LPF is valid	0100_0000b

0xAE[page mode 1]: DAGOFF [default=0x38, r/w]

Bit	Function	Description	Default
B[7:0]	D-LPF	Threshold of AG to disable D-LPF. When AG is under the DAGOFF, D-LPF is invalid	0011_1000b

0xB0[page mode 1]: DDYCTL1 [default=0x11, r/w]

Bit	Function	Description	Default
B[7:2]	D-LPF	Threshold of dynamic range for D-LPF	0001_00b
B[1:0]		Ratio of automatic LPF threshold for D-LPF.	01b

0xB1[page mode 1]: DDYCTL2 [default=0x44, r/w]

Bit	Function	Description	Default
B[7:4]	D-LPF	Threshold of filtering method2 at green color for D-LPF	0100b
B[3:0]		Threshold of filtering method2 at red/blue color for D-LPF	0100b

0xB4[page mode 1]: ZLPFTH1 [default=0x88, r/w]

Bit	Function	Description	Default
B[7:4]	Z-LPF	Threshold of dynamic range of green pixel for Z-LPF	1000b
B[3:0]		Threshold of dynamic range of green pixel for Z-LPF	1000b

0xB5[page mode 1]: ZLPFTH2 [default=0x44, r/w]

Bit	Function	Description	Default
B[7:4]	Z-LPF	Threshold of filtering method2 at green color for Z-LPF	0100b
B[3:0]		Threshold of filtering method2 at red/blue color for Z-LPF	0100b

6.13. Dead Pixel Concealment

0xC0[page mode 1]: DPCCTL [default=0xC3, r/w]

Bit	Function	Description	Default
B[7:2]	DPC	Option for DPC	1100_00b
B[1]		Enable DPC at dark condition [0:OFF, 1:ON]	1b
B[0]		Enable DPC at all condition [0:OFF, 1:ON]	1b

0xC2[page mode 1]: DPCTH [default=0x88, r/w]

Bit	Function	Description	Default
B[7:4]	DPC	Threshold of DPC at dark condition	1000b
B[3:0]		Threshold of DPC at all condition	1000b



6.14. Color Noise Reduction

0xD0[page mode 1]: CNR1CTL[default=0x3F, r/w]

Bit	Function	Description	Default
B[7:1]	Color Noise	Reserved	0011_111b
B[0]	Correction1	Enable the color noise reduction method1 (0:OFF, 1:ON)	1b

0xD1[page mode 1]: CNR1GTH[default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	Color Noise Correction1	Threshold of green color for color noise reduction method1 0x00 ~ 0xff(more color noise reduction)	0100_0000b

0xD2[page mode 1]: CNR1RBTH[default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	Color Noise Correction1	Threshold of red/blue color for color noise reduction method1 0x00 ~ 0xff(more color noise reduction)	0100_0000b

0xD3[page mode 1]: CNR1LVL[default=0xC0, r/w]

Bit	Function	Description	Default
B[7:0]	Color Noise Correction1	Threshold for color noise reduction method1	1100_0000b

0xF0[page mode 1]: CNR2CTL[default=0x00, r/w]

Bit	Function	Description	Default
B[7:4]	Color Noise Correction2	Reserved	0000b
B[3]		Reserved	0b
B[2]		Check the luminance for color noise reduction method2	0b
B[1]		Reserved	0b
B[0]		Enable the color noise reduction method2 (0:OFF, 1:ON)	0b

0xF1[page mode 1]: CNR2TH [default=0x82, r/w]

Bit	Function	Description	Default
B[7:4]	Color Noise	High luminance threshold for color noise reduction method2 High luminance threshold = $128 + B[7:4] \times 8$	1000b
B[3:0]	Reduction2	Edge threshold for color noise reduction method2 Edge threshold = $B[3:0] \times 4$	0010b

0xF2[page mode 1]: CNR2PARA [default=0xAA, r/w]

Bit	Function	Description	Default
B[7:4]	Color Noise	Suppression ratio of positive edge for color noise reduction method2 0x0 (more color noise reduction) ~ 0xf (no color noise reduction)	1010b
B[3:0]	Reduction2	Suppression ratio of negative edge for color noise reduction method2 0x0 (more color noise reduction) ~ 0xf (no color noise reduction)	1010b



0xF8[page mode 1]: CNR4CTL [default=0x88, r/w]

Bit	Function	Description	Default
B[7:5]	Color Noise Reduction4	High luminance threshold for color noise reduction method4 High luminance threshold = $192 + b[7:5] \times 8$	100b
B[4]		Option for color noise reduction method4 (0:OFF, 1:ON)	0b
B[3:1]		Low luminance threshold for color noise reduction method4 Low luminance threshold = $b[3:1] \times 8$	100b
B[0]		Enable color noise reduction method4 (0:OFF, 1:ON)	0b

0xF9[page mode 1]: CNR4PARA1 [default=0x55, r/w]

Bit	Function	Description	Default
B[7:0]	Color Noise Reduction4	Parameter1 for color noise reduction method4 0x00 (more color noise reduction) ~ 0xff (no color noise reduction)	0101_0101b

0xFA[page mode 1]: CNR4PARA2 [default=0xAA, r/w]

Bit	Function	Description	Default
B[7:0]	Color Noise Reduction4	Parameter2 for color noise reduction method4 CNR4PARA2 should be larger than the CNR4PARA1. 0x00 (more color noise reduction) ~ 0xff (no color noise reduction)	1010_1010b

0xFB[page mode 1]: CNR4TH [default=0xF7, r/w]

Bit	Function	Description	Default
B[7:4]	Color Noise Reduction4	High luminance threshold of green color for color noise reduction method4 High luminance threshold = $128 + B[7:4] \times 8$	1111b
B[3:0]	Color Noise Reduction4	Low luminance threshold of green color for color noise reduction method4 Low luminance threshold = $B[3:0] \times 8$	0111b



6.15. Image Scaling

0x10[page mode 2]: ZOOMCTL1 [default=0x00, r/w]

Bit	Function	Description	Default
B[7]	Image Scaling	Reserved	0b
B[6]		Reserved	0b
B[5:3]		Reinforce LPF as image scaling ratio is larger. 0 ~ 5 (more LPF)	00_0b
B[2]		Reserved	00b
B[1]		Enable windowing after image scaling. (0:OFF, 1:ON)	0b
B[0]		Enable image scaling. (0:OFF, 1:ON). When image scaling is enabled, bit[6] of 0x14[P1] should be set to 1.	0b

0x12[page mode 2]: ZOUTWIDTH [default=0x01, r/w]

Bit	Function	Description	Default
B[7:3]	Image Scaling	Reserved	0000_0b
B[2:0]		High byte of image width for image scaling ZOUTWID [10:0]={ZOUTWIDTH[2:0], ZOUTWIDL[7:0]}.	001b

0x13[page mode 2]: ZOUTWIDL [default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	Low byte of image width for image scaling ZOUTWID [10:0]={ZOUTWIDTH[2:0], ZOUTWIDL[7:0]}.	0100_0000b

0x14[page mode 2]: ZOUTHGTH [default=0x00, r/w]

Bit	Function	Description	Default
B[7:3]	Image Scaling	Reserved	0000_0b
B[2:0]		High byte of image height for image scaling ZOUTHGT [10:0]={ZOUTHGTH[2:0], ZOUTHGTL[7:0]}.	000b

0x15[page mode 2]: ZOUTHGTL [default=0xF0, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	Low byte of image height for image scaling ZOUTHGT [10:0]={ZOUTHGTH[2:0], ZOUTHGTL[7:0]}.	1111_0000b

0x16[page mode 2]: ZWINSTXH [default=0x00, r/w]

Bit	Function	Description	Default
B[7:3]	Image Scaling	Reserved	0000_0b
B[2:0]		High byte of column start x address for windowing after image scaling ZWINSTX [10:0]={ZWINWINSXTH[2:0], ZWINWINSTXL[7:0]} + 1.	000b

0x17[page mode 2]: ZWINSTXL [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	Low byte of column start x address for windowing after image scaling ZWINSTX [10:0]={ZWINSTXH[2:0], ZWINSTXL[7:0]} + 1.	0000_0000b

0x18[page mode 2]: ZWINSTYH [default=0x00, r/w]

Bit	Function	Description	Default
B[7:3]		Reserved	0000_0b



B[2:0]	Image Scaling	High byte of row start y address for windowing after image scaling ZWINSTY[10:0]={ZWINSTYH[2:0], ZWINSTYL[7:0]} + 1	000b
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0x19[page mode 2]: ZWINSTYL [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	Low byte of row start y address for windowing after image scaling ZWINSTY [10:0]={ZWINSTYH[2:0], ZWINSTYL[7:0]} + 1.	0000_0000b

0x1A[page mode 2]: ZWINENXH [default=0x04, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	High byte of column end x address for windowing after image scaling ZWINENX [10:0]={ZWINENXH[2:0], ZWINENXL[7:0]}.	0000_0100b

0x1B[page mode 2]: ZWINENXL [default=0xB0, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	Low byte of column end x address for windowing after image scaling ZWINENX [10:0]={ZWINENXH[2:0], ZWINENXL[7:0]}.	1011_0000b

0x1C[page mode 2]: ZWINENYH [default=0x06, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	High byte of row end y address for windowing after image scaling ZWINENY [10:0]={ ZWINEYH[2:0], ZWINENYL[7:0]}.	0000_0110b

0x1D[page mode 2]: ZWINENYL [default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	Low byte of row end y address for windowing after image scaling ZWINENY [10:0]={ZWINEYH[2:0], ZWINENYL[7:0]}.	0100_0000b

0x1E[page mode 2]: ZVERSTEPH [default=0x10, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	High byte of vertical increment step for vertical image scaling ZVERSTEP[15:0]={ZVERSTEPH[7:0], ZVERSTEPL[7:0]}. ZVERSTEP[15:11] = Integer step, ZVERSTEP[10:0] = floating step ZVERSTEP = (Image Height / ZOUTHGT) * 2048, , where Image Height is WINHGT[0x17, 0x18:P0] for full size. Image Height is WINHGT [0x17, 0x18:P0] /2 for preivew1 or preview2	0001_0000b

0x1F[page mode 2]: ZVERSTEPL [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	Low byte of vertical increment step for vertical image scaling ZVERSTEP[15:0]={ZVERSTEPH[7:0], ZVERSTEPL[7:0]}. ZVERSTEP[15:11] = Integer step, ZVERSTEP[10:0] = floating step ZVERSTEP = (Image Height / ZOUTHGT) * 2048, where Image Height is WINHGT[0x17, 0x18:P0] for full size. Image Height is WINHGT [0x17, 0x18:P0] /2 for preivew1 or preview2	0000_0000b

0x20[page mode 2]: ZHORSTEPH [default=0x10, r/w]

Bit	Function	Description	Default
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B[7:0]	Image Scaling	High byte of horizontal increment step for vertical image scaling ZHORSTEP[15:0]={ZHORSTEPH[7:0], ZHORSTEPL[7:0]}. ZHORSTEP[15:11] = Integer step, ZHORSTEP[10:0] = floating step ZHORSTEP = (Image Width / ZOUTWID) * 2048, where Image Width is WINWID[0x19, 0x1A:P0] for preview1 or full size. Image Width is WINWID[0x19, 0x1A:P0] /2 for preivew2	0001_0000b
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0x21[page mode 2]: ZHORSTEPL [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	Low byte of horizontal increment step for vertical image scaling ZHORSTEP[15:0]={ZHORSTEPH[7:0], ZHORSTEPL[7:0]}. ZHORSTEP[15:11] = Integer step, ZHORSTEP[10:0] = floating step ZHORSTEP = (Image Width / ZOUTWID) * 2048, where Image Width is WINWID[0x19, 0x1A:P0] for preview1 or full size. Image Width is WINWID[0x19, 0x1A:P0] /2 for preivew2	0000_0000b

0x22[page mode 2]: ZFIFODLY [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Image Scaling	FIFO delay step for image scaling ZFIFODLY = (Image Width – ZOUTWID) * (ZOUTWID / Image Width) / 4 + 5 where Image Width is WINWID[0x19, 0x1A:P0] for preview1 or full size. Image Width is WINWID[0x19, 0x1A:P0] /2 for preivew2	0000_0000b

6.16. Auto Focus Data

0x30[page mode 2]: AFCTL1 [default=0x00, r/w]

Bit	Function	Description	Default
B[7:6]	Auto Focus	Sampling rate of AF filter3 for AF Type0 0:1, 1:1/2, 2:1/4, 3:1/8	00b
B[5]		Reserved	0b
B[4:3]		Sampling rate of AF filter1,2 for AF Type0 Sampling rate for AF Type1 . 0:1/4, 1:1/8, 2:1/4, 3:1/16	00b
B[2]		0: 5regions are located at cross region for AFType1 1: 5regions are located at star region for AFType1	0b
B[1]		0 : Use 2 region to get AF data : AF Type 0 1 : Use 5 region to get AF data : AF Type1	0b
B[0]		Enable auto focus data (0:OFF, 1:ON)	0b

0x31[page mode 2]: AFCTL2 [default=0x00, r/w]

Bit	Function	Description	Default
B[7]		When input data of AF filter1 is over AFCLIPTH, input data is cut-off for calculating AF data. (0:OFF, 1:ON)	0b
B[6]		When input data of AF filter2 is over AFCLIPTH, input data is cut-off for calculating AF data. (0:OFF, 1:ON)	0b
B[5:4]		Divider of AFVAL3 for using AF type0. Divider of AEDGE3 for using AF type1. 00 : 1/2, 01 : 1/4, 10: 1/8, 11: 1/16	00b



B[3:2]		Divider of AFVAL2 for using AF type0. Divider of AEDGE2(5) for using AF type1. 00 : 1/2, 01 : 1/4, 10: 1/8, 11: 1/16	00b
B[1:0]		Divider of AFVAL1 for using AF type0. Divider of AEDGE1(4) for using AF type1. 00 : 1/2, 01 : 1/4, 10: 1/8, 11: 1/16	00b

0x32[page mode 2]: AFCTL3 [default=0x00, r/w]

Bit	Function	Description	Default
B[7:6]	Data Type	Type of Input data to get edge data 00: luminance data after sharpness 01: luminance data before sharpness 10: green data at color Interpolation 11: luminance data at color interpolation	00b
B[5:4]	AF filter3	Filter type of AFVAL3 for using AF type0. Filter type of AEDGE3 for using AF type1. 00 : Band pass1, 01 : Band Pass2, 10:High pass1, 11:High pass2	00b
B[3:2]	AF filter2	Filter type of AFVAL2 for using AF type0. Filter type of AEDGE2(5) for using AF type1. 00 : Band pass1, 01 : Band Pass2, 10:High pass1, 11:High pass2	00b
B[1:0]	AF filter1	Filter type of AFVAL1 for using AF type0. Filter type of AEDGE1(4) for using AF type1. 00 : Band pass1, 01 : Band Pass2, 10:High pass1, 11:High pass2	00b

0x33[page mode 2]: AFR1XST / AFROW1 [default=0x10, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Focus	X coordinate of start position for defining region1 of AF type0 = Bit[7:0]*8 Row address1 for defining region of AF type1= Bit[7:0]*4	0001_0000b

0x34[page mode 2]: AFR1YST / AFROW2 [default=0x3B, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Y coordinate of start position for defining region1 of AF type0 = Bit[7:0]*8 Row address2 for defining region of AF type1= Bit[7:0]*4	0011_1011b

0x35[page mode 2]: AFR1XEN / AFROW3 [default=0x5B, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Focus	X coordinate of end position for defining region1 of AF type0 = Bit[7:0]*8 Row address3 for defining region of AF type1= Bit[7:0]*4	0101_1011b

0x36[page mode 2]: AFR1YEN [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Y coordinate of end position for defining region1 of AF type0 = Bit[7:0]*8	1000_0000b

0x37[page mode 2]: AFR2XST / AFCOL1 [default=0x10, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Focus	X coordinate of start position for defining region1 of AF type1 = Bit[7:0]*8 Column address1 for defining region of AF type1= Bit[7:0]*4	0001_0000b

0x38[page mode 2]: AFR2YST / AFCOL2 [default=0x54, r/w]



Bit	Function	Description	Default
B[7:0]	Auto Focus	Y coordinate of start position for defining region1 of AF type1 = Bit[7:0]*8 Column address2 for defining region of AF type1= Bit[7:0]*4	0101_0100b

0x39[page mode 2]: AFR2XEN / AFCOL3 [default=0x74, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Focus	X coordinate of end position for defining region1 of AF type1 = B[7:0] * 8 Column address3 for defining region of AF type1 = Bit[7:0]*4	0111_0100b

0x3A[page mode 2]: AFR2YEN [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Y coordinate of end position for defining region1 of AF type1 = Bit[7:0]*8	1000_0000b

0x3B [page mode 2]: AFCLIPTH [default=0xFE, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Focus	AFCLIPTH is cut-off threshold of input data for calculating AF data.	1111_1110b

0x3C [page mode 2]: AFDRVCTL1 [default=0x00, r/w]

Bit	Function	Description	Default
B[7]	Auto Focus	Enable Current Driver for VCM, 0:OFF, 1:ON	0b
B[6:2]		Reserved	000_00b
B[1:0]		Input bit[1:0] of 10bit DAC for controlling VCM	00b

0x3D [page mode 2]: AFDRVCTL2 [default=0x00, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Input bit[9:2] of 10bit DAC for controlling VCM	0000_0000b

0x3E[page mode 2]: AFVAL1R1H/AFEDGE1H [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	High byte of edge data in region1 when AF filter1 is used for AF type0 High byte of edge data in region1 for AF type1	RO

0x3F[page mode 2]: AFVAL1R1L/AFEDGE1L [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Low byte of edge data in region1 when AF filter1 is used for AF type0 Low byte of edge data in region1 for AF type1	RO

0x40[page mode 2]: AFVAL2R1H/AFEDGE2H [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	High byte of edge data in region1 when AF filter2 is used for AF type0 High byte of edge data in region2 for AF type1	RO

0x41[page mode 2]: AFVAL2R1L/AFEDGE2L [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Low byte of edge data in region1 when AF filter2 is used for AF type0 Low byte of edge data in region2 for AF type1	RO

**0x42[page mode 2]: AFVAL1R2H/AFEDGE4H [r]**

Bit	Function	Description	Default
B[7:0]	Auto Focus	High byte of edge data in region2 when AF filter1 is used for AF type0 High byte of edge data in region4 for AF type1	RO

0x43[page mode 2]: AFVAL1R2L/AFEDGE4L [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Low byte of edge data in region2 when AF filter1 is used for AF type0 Low byte of edge data in region4 for AF type1	RO

0x44[page mode 2]: AFVAL2R2H/AFEDGE5H [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	High byte of edge data in region2 when AF filter2 is used for AF type0 High byte of edge data in region5 for AF type1	RO

0x45[page mode 2]: AFVAL2R2L/AFEDGE5L [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Low byte of edge data in region2 when AF filter2 is used for AF type0 Low byte of edge data in region5 for AF type1	RO

0x46[page mode 2]: AFVAL3R1H/AFEDGE3H [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	High byte of edge data in region1 when AF filter3 is used for AF type0 High byte of edge data in region3 for AF type1	RO

0x47[page mode 2]: AFVAL3R1L/AFEDGE3L [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Low byte of edge data in region1 when AF filter3 is used for AF type0 Low byte of edge data in region3 for AF type1	RO

0x48[page mode 2]: AFVAL3R2H [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	High byte of edge data in region2 when AF filter3 is used for AF type0	RO

0x49[page mode 2]: AFVAL3R2L [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Low byte of edge data in region2 when AF filter3 is used for AF type0	RO

0x4A[page mode 2]: YSUMR1H [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	High byte of summed luminance in region1 for AF type0 High byte of summed luminance in all 5 region for AF type1	RO

0x4B[page mode 2]: YSUMR1M [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Middle byte of summed luminance in region1 for AF type0 Middle byte of summed luminance in all 5 region for AF type1	RO

0x4C[page mode 2]: YSUMR1L [r]

Bit	Function	Description	Default
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B[7:0]	Auto Focus	Low byte of summed luminance in region1 for AF type0 Low byte of summed luminance in all 5 region for AF type1	RO
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0x4D[page mode 2]: YSUMR2H [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	High byte of summed luminance in region2 for AF type0 High byte of summed luminance in center region for AF type1	RO

0x4E[page mode 2]: YSUMR2M [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Middle byte of summed luminance in region2 for AF type0 Middle byte of summed luminance in center region for AF type1	RO

0x4F[page mode 2]: YSUMR2L [r]

Bit	Function	Description	Default
B[7:0]	Auto Focus	Low byte of summed luminance in region2 for AF type0 Low byte of summed luminance in center region for AF type1	RO

6.17. Auto Flicker Cancellation

0x50[page mode 2]: FLKMODE [default=0x00, r/w]

Bit	Function	Description	Default
B[7:6]	Auto Flicker Cancellation	Reserved	0000_00b
B[1:0]		Number of skipped frames in Auto flicker cancellation. 00: Reserved, 01: 1 frame, 10: 2frame, 11: 3frame Note) Do not select 0 for auto flicker cancellation	00b

0x51[page mode 2]: FLK200 [default=0x42, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Flicker Cancellation	Number of horizontal line for 1/200sec. $FLK200 = (1/200sec) / \text{horizontal line time}$, where horizontal line time= $(2080 + HBALNK) * OPCLK's \text{ period for full size and preview1}$ $= (1044 + HBALNK0x1B, 0x1C:P0) * OPCLK's \text{ period for preview2}$. When auto-flicker cancellation is enabled, HBLANK should be set to meet that FLK200 and FLK240 are integer.	0100_0010b

0x52[page mode 2]:FLK240 [default=0x37, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Flicker Cancellation	Number of horizontal line for 1/240sec $FLK240 = \text{integer} [(1/240sec) / \text{horizontal line}]$, where horizontal line = $(2080 + HBALNK) * OPCLK's \text{ period for full size and preview1}$ $= (1044 + HBALNK[0x1B, 0x1C:P0]) * OPCLK's \text{ period for preview2}$. When auto-flicker cancellation is enabled, HBLANK should be set to meet that FLK200 and FLK240 are integer.	0011_0111b

0x53[page mode 2]: FLKTH1 [default=0x02, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Flicker	Low Threshold to find flicker condition.	0000_0010b



	Cancellation	When internal calculated value is over FLKTH1 and under FLKTH2, sensor can detect flicker noise(banding noise) on image.	
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0x54[page mode 2]: FLKTH2 [default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Flicker Cancellation	High threshold to find flicker condition. When internal calculated value is over FLKTH1 and under FLKTH2, sensor can detect flicker noise(banding noise) on image.	0010_0000b

0x55[page mode 2]: FLKDET[r]

Bit	Function	Description	Default
B[7:5]	Auto Flicker Cancellation	Reserved	RO
B[4]		0: It indicates that sensor can't detect banding noise in current image. 1: It indicates that sensor detects banding noise in current image.	
B[3:1]		Reserved	
B[0]		It indicates banding time unit in current frame image. 0=120Hz 1=100Hz	

6.18 Image Statistics

0x60 [page mode 2]: ISCTL1 [default=0xF2, r/w]

Bit	Function	Description	Default
B[7:1]	Statistics	Reserved	1111_001b
B[0]		Enable image statistics (0:OFF, 1:ON)	0b

0x61 [page mode 2]: ISCTL2 [default=0x07, r/w]

Bit	Function	Description	Default
B[7]	Statistics	Enable AE parameter3[0x64:P3]	0b
B[6:0]		Reserved	000_0111b

6.19 Lens Shading Correction

0xA0[page mode 2]: LENSCTL1[default=0x00, r/w]

Bit	Function	Description	Default
B[7:2]	Lens Shading Correction	Reserved	0000_00b
B[1]		Enable or Disable lens shading correction automatically as AG (0:OFF, 1:ON) Bit[0] should be enabled for this function. Refer to LAGOFF[0xD6:P2] and LAGON[0xD7:P2].	0b
B[0]		Enable lens shading correction (0:OFF, 1:ON)	0b

0xA1[page mode 2]: LENSCTL2[default=0x0B, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Option for Lens Shading Correction (0:OFF, 1:ON)	0000_1011b

0xA2[page mode 2]: XCEN[default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading	It indicates optical center point on x-axis of pixel array to compensate lens shading.	1000_0000b



	Correction	Optical center on x-axis = 896 + b[7:0]	
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0xA3[page mode 2]: YCEN[default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	It indicates optical center point on y-axis of pixel array to compensate lens shading. Optical center on y-axis = 640 + b[7:0]	1000_0000b

0xA6[page mode 2]: LENSGrP1[default=0x0A, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter1 for Gr Pixel 0x00 (1x) ~ 0xFF(4.99x)	0000_1010b

0xA7[page mode 2]: LENSGrP2[default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter2 for Gr Pixel 0x00 (1x) ~ 0xFF(4.99x)	0010_0000b

0xA8[page mode 2]: LENSGrP3[default=0x30, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter3 for Gr Pixel 0x00 (1x) ~ 0xFF(4.99x)	0011_0000b

0xA9[page mode 2]: LENSGrP4[default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter4 for Gr Pixel 0x00 (1x) ~ 0xFF(4.99x)	0100_0000b

0xAA[page mode 2]: LENSGrP5[default=0x50, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter5 for Gr Pixel 0x00 (1x) ~ 0xFF(4.99x)	0101_0000b

0xAB[page mode 2]: LENSGrP6[default=0x60, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter6 for Gr Pixel 0x00 (1x) ~ 0xFF(4.99x)	0110_0000b

0xAC[page mode 2]: LENSGrP7[default=0x70, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter7 for Gr Pixel 0x00 (1x) ~ 0xFF(4.99x)	0111_0000b

0xAD[page mode 2]: LENSGrP8[default=0x70, r/w]



Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter8 for Gr Pixel 0x00 (1x) ~ 0xFF(4.99x)	0111_0000b

0xAE[page mode 2]: LENS RP1[default=0x0A, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter1 for Red Pixel 0x00 (1x) ~ 0xFF(4.99x)	0000_1010b

0xAF[page mode 2]: LENS RP2[default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter2 for Red Pixel 0x00 (1x) ~ 0xFF(4.99x)	0010_0000b

0xB0[page mode 2]: LENS RP3[default=0x30, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter3 for Red Pixel 0x00 (1x) ~ 0xFF(4.99x)	0011_0000b

0xB1[page mode 2]: LENS RP4[default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter4 for Red Pixel 0x00 (1x) ~ 0xFF(4.99x)	0100_0000b

0xB2[page mode 2]: LENS RP5[default=0x50, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter5 for Red Pixel 0x00 (1x) ~ 0xFF(4.99x)	0101_0000b

0xB3[page mode 2]: LENS RP6[default=0x60, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter6 for Red Pixel 0x00 (1x) ~ 0xFF(4.99x)	0110_0000b

0xB4[page mode 2]: LENS RP7[default=0x70, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter7 for Red Pixel 0x00 (1x) ~ 0xFF(4.99x)	0111_0000b

0xB5[page mode 2]: LENS RP8[default=0x70, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter8 for Red Pixel 0x00 (1x) ~ 0xFF(4.99x)	0111_0000b



	Correction		
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0xB6[page mode 2]: LENSGBP1[default=0x0A, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter1 for Gb Pixel 0x00 (1x) ~ 0xFF(4.99x)	0000_1010b

0xB7[page mode 2]: LENSGBP2[default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter2 for Gb Pixel 0x00 (1x) ~ 0xFF(4.99x)	0010_0000b

0xB8[page mode 2]: LENSGBP3[default=0x30, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter3 for Gb Pixel 0x00 (1x) ~ 0xFF(4.99x)	0011_0000b

0xB9[page mode 2]: LENSGBP4[default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter4 for Gb Pixel 0x00 (1x) ~ 0xFF(4.99x)	0100_0000b

0xBA[page mode 2]: LENSGBP5[default=0x50, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter5 for Gb Pixel 0x00 (1x) ~ 0xFF(4.99x)	0101_0000b

0xBB[page mode 2]: LENSGBP6[default=0x60, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter6 for Gb Pixel 0x00 (1x) ~ 0xFF(4.99x)	0110_0000b

0xBC[page mode 2]: LENSGBP7[default=0x70, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter7 for Gb Pixel 0x00 (1x) ~ 0xFF(4.99x)	0111_0000b

0xBD[page mode 2]: LENSGBP8[default=0x70, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter8 for Gb Pixel 0x00 (1x) ~ 0xFF(4.99x)	0111_0000b



0xBE[page mode 2]: LENSBP1[default=0x0A, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter1 for Blue Pixel 0x00 (1x) ~ 0xFF(4.99x)	0000_1010b

0xBF[page mode 2]: LENSBP2[default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter2 for Blue Pixel 0x00 (1x) ~ 0xFF(4.99x)	0010_0000b

0xC0[page mode 2]: LENSBP3[default=0x30, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter3 for Blue Pixel 0x00 (1x) ~ 0xFF(4.99x)	0011_0000b

0xC1[page mode 2]: LENSBP4[default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter4 for Blue Pixel 0x00 (1x) ~ 0xFF(4.99x)	0100_0000b

0xC2[page mode 2]: LENSBP5[default=0x50, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter5 for Blue Pixel 0x00 (1x) ~ 0xFF(4.99x)	0101_0000b

0xC3[page mode 2]: LENSBP6[default=0x60, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter6 for Blue Pixel 0x00 (1x) ~ 0xFF(4.99x)	0110_0000b

0xC4[page mode 2]: LENSBP7[default=0x70, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter7 for Blue Pixel 0x00 (1x) ~ 0xFF(4.99x)	0111_0000b

0xC5[page mode 2]: LENSBP8[default=0x70, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	Lens Shading Correction Gain Parameter8 for Blue Pixel 0x00 (1x) ~ 0xFF(4.99x)	0111_0000b

0xD6[page mode 2]: LAGOFF[default=0x60, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading	When AG is over LAGOFF and bit[1] of LENSCTL is enabled, lens shading correction is	0110_0000b



	Correction	disabled automatically.	
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0xD7[page mode 2]: LAGON[default=0x60, r/w]

Bit	Function	Description	Default
B[7:0]	Lens Shading Correction	When AG is under LAGON and bit[1] of LENSCTL is enabled, lens shading correction is enabled automatically.	0110_0000b



6.20. Auto Exposure

0x10[page mode 3]: AECTL1[default=0x0C, r/w]

Bit	Function	Description	Default
B[7]	AE Enable	Enable auto exposure. (0:OFF, 1:ON) When this bit is disabled, AFC(Auto Flicker Cancellation) operation is also disabled.	0b
B[6]	Auto Anti-Flicker	Sensor detects the frequency of fluorescent lamp and adjusts exposure time to multiple of period of the frequency automatically. (0:OFF, 1:ON)	0b
B[5]		Reserved	0b
B[4]	120Hz/100Hz	On canceling flicker manually, user should select the frequency of a fluorescent lamp. 0: 120Hz, 1: 100Hz	0b
B[3:0]	AE Mode	1001: AG (Automatic Adjustment), Exposure Time (Fixation) 1011: AG (Fixation), Exposure Time (Automatic Adjustment) 1100: AG (Automatic Adjustment), Exposure Time (Automatic Adjustment)	1100b

0x11[page mode 3]: AECTL2[default=0x80, r/w]

Bit	Function	Description	Default
B[7:1]		Reserved	1000_000b
B[0]	AE WEIGHT	Enable AE weight (0:OFF, 1:ON):	0b

0x12[page mode 3]: AECTL3[default=0x30, r/w]

Bit	Function	Description	Default
B[7:4]		Reserved	0011b
B[3]	Initial AE	When sensor has unstable AE operation by inappropriate setting, this bit can initialize internal AE status. To use this mode, Auto exposure(bit[7] of AECTL1) should be turned off. (0:OFF, 1:ON)	0b
B[2]		Reserved	0b
B[1:0]	Speed to detect Flicker Noise	Speed to detect flicker noise for auto flicker cancellation : (fast speed) 00 ~ 11 (slow speed)	00b

0x13[page mode 3]: AECTL4[default=0xA5, r/w]

Bit	Function	Description	Default
B[7:4]		Reserved	1010b
B[3]	Convergence Speed2	When overall luminance of current frame is far from a internal target level, it controls speed to converge on internal target level. 0: slow, 1: fast	0b
B[2:1]	Convergence Speed1	When overall luminance of current frame is not near to a internal target level and not far from to a internal target level, it controls speed to converge on internal target level. (slow) 00 ~ 11 (fast)	10b
B[0]	Convergence Speed0	When overall luminance of current frame is near to a internal target level, it controls speed to converge on internal target level. 0: slow, 1: fast	1b

0x14[page mode 3]: AECTL5[default=0x30, r/w]

Bit	Function	Description	Default
B[7:0]	AE	It is used as option to control AE speed.	0011_0000b



0x15[page mode 3]: AECTL6[default=0x51, r/w]

Bit	Function	Description	Default
B[7]	AE	Reserved	0b
B[6]		Enable Adaptive AG (0: OFF, 1:ON)	1b
B[5:3]		Reserved	01_0b
B[2:0]		The ratio of AE parameter1 . 0(small) ~ 7(large)	001b

0x16[page mode 3]: AECTL7[default=0x07, r/w]

Bit	Function	Description	Default
B[7:4]	AE	Reserved	0000b
B[3]		Enable AE parameter1 (0: OFF, 1:ON)	0b
B[2]		Enable AE parameter2 (0: OFF, 1:ON)	1b
B[1]		Reserved	1b
B[0]		Reserved	1b

0x17[page mode 3]: AECTL8 [default=0x25, r/w]

Bit	Function	Description	Default
B[7:6]	AE	Reserved	00b
B[5]		0 : control luminance offset for brightness 1 : control AE luminance target level for brightness	1b
B[4:0]		Reserved	0_0101b

0x19[page mode 3]: AECTL9 [default=0x70, r/w]

Bit	Function	Description	Default
B[7:1]	AE	Reserved	0111_000b
B[0]		Enable image statistics for auto exposure (0:OFF, 1:ON)	0b

0x1C[page mode 3]:YLVL [default=0x50, r/w]

Bit	Function	Description	Default
B[7:0]	AE	YLVL is luminance level to converge in AE operation.	0101_0000b

0x1D[page mode 3]:YTH1 [default=0x45, r/w]

Bit	Function	Description	Default
B[7:4]	AE	Marginal range of Y convergence level in AE operation. Unit is 1 and default is 4	0100b
B[3:0]	AE	Hysteresis range1 in AE operation. Unit is 2, and default is 10	0101b

0x1E[page mode 3]:YTH2 [default=0x28, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Hysteresis range2 in AE operation. Unit is 1 and default is 40.	0010_1000b

0x20 [page mode 3]:AHXOFS [default=0x04, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Horizontal x start position to divide image area	0000_0100b

0x21 [page mode 3]:AVYOFS [default=0x04, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Vertical y start position to divide image area	0000_0100b



0x22 [page mode 3]: AHWID1 [default=0xFB, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Horizontal width1 of divided image area. It should be under AHWID2[0x24:P3]	1111_1011b

0x23 [page mode 3]: AVHGT1 [default=0xA7, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Vertical height1 of a divided image area. It should be under AVHGT2[0x25:P3]	1010_0111b

0x24 [page mode 3]: AHWID2 [default=0xFD, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Horizontal width2 for a divided image area. Max value is 0xC5. It should be odd number. It is the integer $((WINWIDTH - AHOFS) / 8) - 2$, Example) integer $((2048 - 4) / 8) - 2 = 253$ decimal = 0xFD, where WINWID[0x19, 0x1A:P0] = 2048 and AHOFS[0x20:P3] = 4	1111_1101b

0x25 [page mode 3]: AVHGT2 [default=0xA9, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Vertical height2 for a divided image area. Max value is 0x93. It should be odd number. It is the integer $((WINHGT - AVOFS) / 8) - 2$. Example) integer $((1536 - 4) / 8) - 2 = 189$ decimal = 0xBD, where WINHGT[0x17, 0x18:P0] = 1536 and AVOFS[0x21:P3] = 4	1010_1001b

0x26 [page mode 3]: AEWGT [default=0x95, r/w]

Bit	Function	Description	Default
B[7:6]	AE	Center area weighting, 00 : 0x, 01 : 1x, 10 : 2x, 11 : 4x	10b
B[5:4]		Top area weighting, 00 : 0x, 01 : 1x, 10 : 2x, 11 : 4x	01b
B[3:2]		Bottom area weighting, 00 : 0x, 01 : 1x, 10 : 2x, 11 : 4x	01b
B[1:0]		Side area weighting, 00 : 0x, 01 : 1x, 10 : 2x, 11 : 4x	01b

Image Area is divided by center, top, bottom and side area for AE operation. User can set each area to separate weighting value.

0x30 [page mode 3]: EXPINTH [r]

Bit	Function	Description	Default
B[7:0]	AE	High byte of internal exposure time EXPINT[23:0] = {EXPINTH[7:0], EXPINTM[7:0], EXPINTL[7:0]} EXPINT is internal exposure time in current frame. Example) EXPINTH=0x01, EXPINTM=0x86, EXPINTL=0xA0, period of OPCLK=41.666ns (MCLK=24MHz, PLL=2x, OPCLK=24MHz) EXPTIME = 0x01_86_A0 = 100000 decimal. Exposure time = 100,000 X 8 X 41.666ns = 33.333ms	RO

0x31 [page mode 3]: EXPINTM [r]

Bit	Function	Description	Default
B[7:0]	AE	Middle byte of internal exposure time	RO

0x32 [page mode 3]: EXPINTL [r]

Bit	Function	Description	Default
B[7:0]	AE	Low byte of internal exposure time	RO



0x33[page mode 3]: EXPTIMEH [default=0x01, r/w]

Bit	Function	Description	Default
B[7:0]	AE	<p>High byte of manual exposure time</p> <p>EXPTIME[23:0] = {EXPTIMEH[7:0], EXPTIMEM[7:0], EXPTIMEL[7:0]}</p> <p>EXPTIME is exposure time that makes pixel element to accumulate photons and convert electrons. Since the brightness of image may change by amount of exposure time, user should control the exposure time adequately. However, user does not need to control exposure time on auto exposure. The unit of exposure time is 8 times of OPCLK's period.</p> <p>Example) EXPTIMEH=0x01, EXPTIMEM=0x86, EXPTIMEL=0xA0, period of OPCLK=41.666ns (MCLK=24MHz, PLL=2x, OPCLK=24MHz)</p> <p>EXPTIME = 0x01_86_A0 = 100000 decimal.</p> <p>Exposure time = 100,000 X 8 X 41.666ns = 33.333ms</p>	0000_0001b

0x34[page mode 3]: EXPTIMEM [default=0x86, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Middle byte of manual exposure time	1000_0110b

0x35[page mode 3]: EXPTIMEL [default=0xA0, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Low byte of manual exposure time	1010_0000b

0x36[page mode 3]: EXPMINH [default=0x01, r/w]

Bit	Function	Description	Default
B[7:0]	AE	<p>High byte of minimum exposure time</p> <p>EXPMIN = {EXPMINH, EXPMINL}</p> <p>EXPMIN is minimum time of EXPTIME in AE operation. User should set EXPTIME[0x33, 0x34, 0x35] over EXPMIN and EXPMIN should be greater than HBLANK /8.</p> <p>Example) EXPMINH=0x01, EXPMINL=0x7C, period of OPCLK=41.666ns (MCLK=24MHz, PLL=2x, OPCLK=24MHz)</p> <p>EXPMIN = 0x01_C8 = 456 decimal.</p> <p>Minimum exposure time = 456 X 8 X 41.666ns = 151.997us</p>	0000_0001b

0x37[page mode 3]: EXPMINL [default=0xC8, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Low byte of minimum exposure time	1100_1000b

0x38[page mode 3]: EXPMAXH [default=0x09, r/w]

Bit	Function	Description	Default
B[7:0]	AE	<p>High byte of maximum exposure time</p> <p>EXPMAX[23:0] = {EXPMAXH[7:0], EXPMAXM[7:0], EXPMAXL[7:0]}</p> <p>EXPMAX is maximum time of EXPTIME in AE operation.</p> <p>EXPMAX should multiple of EXP100(EXP120) for 100Hz(120Hz) flicker cancellation.</p> <p>When auto anti-flicker cancellation is enabled, EXPMAX should be multiple of 50msec.</p> <p>Example) EXPMAXH=0x09, EXPMAXM=0x27, EXPMAXL=0xC0, period of OPCLK=41.666ns (MCLK=24MHz, PLL=2x, OPCLK=24MHz)</p> <p>EXPMAX = 0x09_27_C0 = 600000 decimal.</p> <p>Maximum exposure time = 600,000 X 8 X 41.666ns = 200ms</p>	0000_1001b

**0x39[page mode 3]: EXPMAXM [default=0x27, r/w]**

Bit	Function	Description	Default
B[7:0]	AE	Middle byte of maximum exposure time	0010_0111b

0x3A[page mode 3]: EXPMAXL [default=0xC0, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Low byte of maximum exposure time	1100_0000b

0x3B[page mode 3]: EXP100H [default=0x75, r/w]

Bit	Function	Description	Default
B[7:0]	AE/ AFC(Auto Flicker Cancellation)	High byte of exposure time for 1/100sec EXP100[15:0] = {EXP100H[7:0], EXP100L[7:0]} EXP100 is anti-flickering exposure time step for 100Hz. The unit of exposure time is 8 times of OPCLK's period (1 pixel clock period). Example) EXP100 = anti-flickering exposure time step for 100Hz / (8 X period of OPCLK), = 10ms / (8 X 41.666ns) = 30000(decimal)= 0x7530 where MCLK = 24MHz and PLL=2x and OPCLK =24MHz	0111_0101b

0x3C[page mode 3]: EXP100L [default=0x30, r/w]

Bit	Function	Description	Default
B[7:0]	AE/AFC	Low byte of exposure time for 1/100sec	0011_0000b

0x3D[page mode 3]: EXP120H [default=0x61, r/w]

Bit	Function	Description	Default
B[7:0]	AE/AFC	High byte of exposure time for 1/120sec EXP120[15:0] = {EXP120H[7:0], EXP120L[7:0]} EXP120 is anti-flickering exposure time step for 120Hz. The unit of exposure time is 8 times of OPCLK's period (1 pixel clock period). Example) EXP120 = anti-flickering exposure time step for 120Hz / (8 X period of OPCLK), = 8.3333ms / (8 X 41.666ns) = 25000(decimal)= 0x61A8 where MCLK = 24MHz and PLL =2x and OPCLK =24MHz	0110_0001b

0x3E[page mode 3]: EXP120L [default=0xA8, r/w]

Bit	Function	Description	Default
B[7:0]	AE/AFC	Low byte of exposure time for 1/120sec	1010_1000b

0x3F[page mode 3]: EXPDPCH [default=0x04, r/w]

Bit	Function	Description	Default
B[7:0]	DPC	High byte of exposure time for dead pixel concealment EXPDPCH[15:0] = {EXPDPCH[7:0], EXPDPCL[7:0]} DPC1(Dead pixel concealment) is operated by enabling bit[1] of DPCCTL[0xC0:P1] when exposure time[EXPTIME] is larger than EXPDPC. Example) EXPDPCH=0x03, EXPDPCL=0x00, period of OPCLK=41.666ns (MCLK=24MHz, PLL=2x, OPCLK=24MHz) EXPDPCH = 0x04_93= 1171 decimal. DPC exposure time = 1171 X 2048 X 41.666ns = 99.925ms	0000_0100b



0x40[page mode 3]: EXPDPCL [default=0x93, r/w]

Bit	Function	Description	Default
B[7:0]	DPC	Low byte of exposure time for dead pixel concealment	1001_0011b

0x41[page mode 3]: EXPFIXH [default=0x12, r/w]

Bit	Function	Description	Default
B[7:0]	FFR (Fixed Frame Rate)	High byte of exposure time for fixed frame rate EXPFIX[23:0]= {EXPFIXH[7:0], EXPFIXM[7:0], EXPFIXL[7:0]} EXPFIX makes Frame Time constant by enabling bit[2] of VDOCTL2[0x11:P0] regardless of the change of exposure time . Refer to 5.17[Fixed Frame Rate Timing] Frame Time = EXPFIX time + VSYNC time Example) EXPFIXH=0x12, EXPFIXM=0x4F, EXPFIXL=0x80, period of OPCLK=41.666ns (MCLK=24MHz, PLL=2x, OPCLK=24MHz) EXPFIX = 0x12_4F_80 = 1,200,000 decimal. Exposure time for fixed frame rate= 1,200,000 X 8 X 41.666ns = 400ms	0001_0010b

0x42[page mode 3]: EXPFIXM [default=0x4F, r/w]

Bit	Function	Description	Default
B[7:0]	FFR	Middle byte of exposure time for fixed frame rate	0100_1111b

0x43[page mode 3]: EXPFIXL [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	FFR	Low byte of exposure time for fixed frame rate	1000_0000b

0x44[page mode 3]: EXPINCH [r]

Bit	Function	Description	Default
B[7:0]	FFR	High byte of maximum exposure time for fixed frame rate EXPINC[23:0]= {EXPINCH[7:0], EXPINCM[7:0], EXPINCL[7:0]} EXPINC is maximum exposure time of current frame when fixed frame rate is used. When AE is off, user should not set exposure time over this value.	RO

0x45[page mode 3]: EXPINCM [r]

Bit	Function	Description	Default
B[7:0]	FFR	Middle byte of maximum exposure time for fixed frame rate	RO

0x46[page mode 3]: EXPINCL [r]

Bit	Function	Description	Default
B[7:0]	FFR	Low byte of maximum exposure time for fixed frame rate	RO

0x48[page mode 3]: BRPTIMETH [default=0x9A, r/w]

Bit	Function	Description	Default
B[7:4]	LPF	Exposure time threshold to enter into bright condition = bit[7:4] * time unit. where time unit = EXPFINE, for bit[2] of AECTL2[0x11:P3] = 0, = 1/1920sec, elsewhere. It is used to control automatic LPF and auto white balance.	1001b
B[3:0]	LPF	Exposure time threshold to escape from bright condition = bit[3:0] * time unit. where time unit = EXPFINE, for bit[2] of AECTL2[0x11:P3] = 0, = 1/1920sec, elsewhere.	1010b



0x4C[page mode 3]: EXPFINEH [default=0x09, r/w]

Bit	Function	Description	Default
B[7:0]	AE/AFC	High byte of exposure time for 1/1200sec EXPFINE[15:0] = {EXPFINE[7:0], EXP120L[7:0]} It is used as unit of exposure time to process AE or AWB at outdoor condition. The unit of exposure time is 8 times of OPCLK's period (1 pixel clock period). Example) EXPFINEH=0x09, EXPFINEL=0xC0, period of OPCLK=41.666ns (MCLK=24MHz, PLL=2x, OPCLK=24MHz) EXPFINE = 0x09_C4 = 2500 decimal. Fine exposure time = 2500 X 8 X 41.666ns = 0.8333ms	0000_1001b

0x4D[page mode 3]: EXPFINEL [default=0xC4, r/w]

Bit	Function	Description	Default
B[7:0]	AE/AFC	Low byte of exposure time for 1/1200sec	1100_0100b

0x4E[page mode 3]: AECTL10[default=0x01, r/w]

Bit	Function	Description	Default
B[7:1]	AE	Reserved.	0000_000b
B[0]		Option for smooth AE operation	1b

0x50[page mode 3]:AG [default=0x10, r/w]

Bit	Function	Description	Default
B[7:0]	AE	AG is common gain for R, G and B channel and is used for AE operation. AG = 1 + B[7:0]/17. Programmable range is from 1x(0dB) to 16x(24dB)	0001_0000b

0x51[page mode 3]:AGMIN [default=0x10, r/w]

Bit	Function	Description	Default
B[7:0]	AE	AGMIN is minimum AG in AE operation. AGMIN should be under the AGTH1[0x54:P3]. AGMIN = 1 + B[7:0]/17.	0001_0000b

0x52[page mode 3]:AGMAX [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	AE	AGMAX is maximum AG in AE operation. AGMAX should be over the AGTH2[0x55:P3]. AGMAX = 1 + B[7:0]/17.	1000_0000b

0x53[page mode 3]:AGLVL [default=0x10, r/w]

Bit	Function	Description	Default
B[7:0]	AE	AGLVL is target of AG to converge on abrupt transition AGLVL should be over the AGTH1[0x54:P3] and under the AGTH2[0x55:P3] AGLVL = 1 + B[7:0]/17.	0001_0000b

0x54[page mode 3]:AGTH1 [default=0x10, r/w]

Bit	Function	Description	Default
B[7:0]	AE	AGTH1 is lower limit of AG, when exposure time is from 1/100sec(1/120sec) to EXPMAX. AGTH1 should be over the AGMIN[0x51:P3] and under the AGLVL[0x53:P3] AGTH1 = 1 + B[7:0]/17.	0001_0000b



0x55[page mode 3]:AGTH2 [default=0x33, r/w]

Bit	Function	Description	Default
B[7:0]	AE	AGTH2 is upper limit of AG, when exposure time is from 1/100sec(1/120sec) to EXPMAX. AGTH2 should be over the AGLVL[0x53:P3] and under the AGMAX[0x52:P3] AGTH2 = 1 + B[7:0]/17.	0011_0011b

0x56[page mode 3]:AGDPC [default=0x60, r/w]

Bit	Function	Description	Default
B[7:0]	DPC	When AG is greater than AGDPC and bit[1] of DPCCTL[0xC0:P1] is ON, DPC1(Dead Pixel Concealment 1) is performed automatically. AGDPC = 1 + B[7:0]/17.	0110_0000b

0x57[page mode 3]:AGSAT [default=0x60, r/w]

Bit	Function	Description	Default
B[7:0]	Color Saturation	When AG is greater than AGSAT, auto color de-saturation is performed by setting bit[3:1] of SATCTL[0x20:P1]. AGSAT = 1 + B[7:0]/17.	0110_0000b

0x58[page mode 3]:AGBRT [default=0x60, r/w]

Bit	Function	Description	Default
B[7:0]	Auto Bright	When AG is greater than AGBRT at dark environment by auto exposure control, sensor controls luminance by enabling bit[5] of ISPCTL3[0x12:P1] and setting DYOFFS[0x1A:P1]. AGBRT = 1 + B[7:0]/17.	0110_0000b

0x59[page mode 3]: AGBTH1 [default=0x22, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Threshold1 of Adaptive AG in AE. It should be over the AGBTH2[0x5A:P3] and under the AGTH2 [0x55:P3] AGBTH1 = 1 + B[7:0]/17.	0010_0010b

0x5A[page mode 3]: AGBTH2 [default=0x1C, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Threshold2 of Adaptive AG in AE. It should be over the AGBTH3[0x5B:P3] and under the AGBTH1 [0x59:P3] AGBTH2 = 1 + B[7:0]/17.	0001_1100b

0x5B[page mode 3]: AGBTH3 [default=0x19, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Threshold3 of Adaptive AG in AE. It should be over the AGBTH4[0x5C:P3] and under the AGBTH2 [0x5A:P3] AGBTH3 = 1 + B[7:0]/17	0001_1001b

0x5C [page mode 3]: AGBTH4 [default=0x17, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Threshold4 of Adaptive AG in AE. It should be over the AGBTH5[0x5C:P3] and under the AGBTH3 [0x5B:P3] AGBTH4 = 1 + B[7:0]/17	0001_0111b



0x5D[page mode 3]: AGBTH5 [default=0x15, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Threshold5 of Adaptive AG in AE. It should be over the AGTH1[0x54:P3] and under the AGBTH4 [0x5C:P3] $AGBTH5 = 1 + B[7:0]/17$	0001_0101b

0x5E[page mode 3]: AGBTH6 [default=0x14, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Threshold6 of Adaptive AG in AE. It should be over the AGTH1[0x54:P3] and under the AGBTH5 [0x5D:P3] $AGBTH5 = 1 + B[7:0]/17$	0001_0100b

0x5F[page mode 3]: AGBTH7 [default=0x13, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Threshold7 of Adaptive AG in AE. It should be over the AGTH1[0x54:P3] and under the AGBTH6 [0x5E:P3] $AGBTH5 = 1 + B[7:0]/17$	0001_0011b

0x60[page mode 3]: AGBTH8 [default=0x12, r/w]

Bit	Function	Description	Default
B[7:0]	AE	Threshold8 of Adaptive AG in AE. It should be over the AGTH1[0x54:P3] and under the AGBTH7 [0x5F:P3] $AGBTH5 = 1 + B[7:0]/17$	0001_0010b

0xD3[page mode 3]: YAVG [r]

Bit	Function	Description	Default
B[7:0]	AE	Average of luminance in frame	RO



6.21. Auto White Balance

0x10[page mode 4]: AWBCTL1[default=0x6B, r/w]

Bit	Function	Description	Default
B[7]	AWB	Enable Automatic White Balance (0: OFF, 1: ON)	0b
B[6:4]		The update speed of AWB (slow) 000 ~ 111 (fast)	110b
B[3:2]		When current image is far from the target of AWB, the step of R/B gain to change. 00(small step) ~ 11(large step)	10b
B[1]		When current image is near to the target of AWB, the step of R/B gain to change. 0(small step) ~ 1(large step)	1b
B[0]		0: Same Step 1: Adaptive Step	1b

0x11[page mode 4]: AWBCTL2[default=0x28, r/w]

Bit	Function	Description	Default
B[7:4]	AWB	Reserved	0010b
B[3]		Use color offset for color correction (0:OFF, 1:ON)	1b
B[2]		Use the relation of RGAIN and BGAIN (0:OFF, 1:ON)	0b
B[1]		Change the boundary of RGAIN and BGAIN (0:OFF, 1:ON)	0b
B[0]		Enable manual white balance (0:OFF, 1:ON)	0b

0x20[page mode 4]: UVTH1 [default=0x13, r/w]

Bit	Function	Description	Default
B[7:4]	AWB	Marginal range of white U/V convergence level in AWB operation	0001b
B[3:0]	AWB	Hysteresis range1 of white U/V in AWB operation	0011b

0x21[page mode 4]: UVTH2 [default=0x66, r/w]

Bit	Function	Description	Default
B[7:4]	AWB	B[7:4]*2 is Hysteresis range2 of white U/V in AWB operation	0110b
B[3:0]	AWB	B[3:0]*8 is Hysteresis range3 of white U/V in AWB operation	0110b

0x23[page mode 4]: YRANGE [default=0x88, r/w]

Bit	Function	Description	Default
B[7:4]	AWB	YMAX is maximum luminance to find white pixel. $YMAX = 128 + B[7:4]*8$.	1000b
B[3:0]		YMIN is minimum luminance to find white pixel. $YMIN = B[3:0]*8$.	1000b

0x24[page mode 4]: CDIFF [default=0x88 r/w]

Bit	Function	Description	Default
B[7:4]	AWB	It is high threshold of the difference between U and V and is used to find the white pixel	1000b
B[3:0]		It is low threshold of the difference between U and V and is used to find the white pixel	1000b

0x25[page mode 4]: CSUM [default=0x66, r/w]

Bit	Function	Description	Default
B[7:4]	AWB	It is high threshold of the summation of U and V and is used to find the white pixel.	0110b
B[3:0]		It is low threshold of the summation of U and V and is used to find the white pixel.	0110b

0x2C[page mode 4]: WHTPXLTH [default=0x0A, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Threshold of white pixels in frame.	0000_1010b



0x40[page mode 4]: RGAIN [default=0x30, r/w]

Bit	Function	Description	Default
B[7]		Reserved	0b
B[6:0]	AWB	RGAIN (Red Color Gain) = $0.5 + B[6:0]/64$ (0.5 ~ 2.5x) Sensor has red, green, and blue color gain respectively. User can control white balance manually by setting these value and bit[7] of AWBCTL1[0x0E]=OFF.	011_0000b

0x41[page mode 4]: GGAIN [default=0x20, r/w]

Bit	Function	Description	Default
B[7]		Reserved	0b
B[6:0]	AWB	GGAIN (Green Color Gain) = $0.5 + B[6:0]/64$ (0.5 ~ 2.5x) Sensor has red, green, and blue color gain respectively. User can control white balance manually by setting these value and bit[7] of AWBCTL1[0x0E]=OFF.	010_0000b

0x42[page mode 4]: BGAIN [default=0x38, r/w]

Bit	Function	Description	Default
B[7]		Reserved	0b
B[6:0]	AWB	BGAIN (Blue Color Gain) = $0.5 + B[6:0]/64$ (0.5 ~ 2.5x) Sensor has red, green, and blue color gain respectively. User can control white balance manually by setting these value and bit[7] of AWBCTL1[0x0E]=OFF.	011_1000b

0x43[page mode 4]: RMAX [default=0x50, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	It is maximum of RGAIN. $RMAX = 0.5 + B[6:0]/64$. Default is 1.75x	0101_0000b

0x44[page mode 4]: RMIN [default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	It is minimum of RGAIN. $RMIN = 0.5 + B[6:0]/64$. Default is 1.0x	0010_0000b

0x45[page mode 4]: BMAX [default=0x50, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	It is maximum of BGAIN. $BMAX = 0.5 + B[6:0]/64$. Default is 1.75x	0101_0000b

0x46[page mode 4]: BMIN [default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	It is minimum of BGAIN. $BMIN = 0.5 + B[6:0]/64$. Default is 1.0x	0010_0000b

0x47[page mode 4]: RMAXB [default=0x50, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	It is maximum of RGAIN at bright condition. $RMAXB = 0.5 + B[6:0]/64$. Default is 1.75x	0101_0000b

0x48[page mode 4]: RMINB [default=0x3E, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	It is minimum of RGAIN at bright condition. $RMINB = 0.5 + B[6:0]/64$. Default is 1.47x	0011_1110b

0x49[page mode 4]: BMAXB [default=0x2E, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	It is maximum of BGAIN at bright condition. $BMAXB = 0.5 + B[6:0]/64$. Default is 1.22x	0010_1110b



0x4A[page mode 4]: BMINB [default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	It is minimum of BGAIN at bright condition. $BMINB = 0.5 + B[6:0]/64$. Default is 1.0x	0010_0000b

0x4B[page mode 4]: REXPLMT [default=0x08, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Threshold of exposure time to change the boundary of RGAIN. where time unit = EXPFINE, for bit[2] of AECTL2[0x11;P3] = 0, = 1/1920sec, elsewhere.	0000_1000b

0x4C[page mode 4]: BEXPLMT [default=0x08, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Threshold of exposure time to change the boundary of BGAIN. where time unit = EXPFINE, for bit[2] of AECTL2[0x11;P3] = 0, = 1/1920sec, elsewhere.	0000_1000b

0x4D[page mode 4]: RDELTA [default=0x04, r/w]

Bit	Function	Description	Default
B[7:4]	AWB	The amount of increasing step to change the boundary of RGAIN	0000b
B[3:0]	AWB	The amount of decreasing step to change the boundary of RGAIN	0100b

0x4E[page mode 4]: BDELTA [default=0x60, r/w]

Bit	Function	Description	Default
B[7:4]	AWB	The amount of increasing step to change the boundary of BGAIN	0110b
B[3:0]	AWB	The amount of decreasing step to change the boundary of BGAIN	0000b

0x4F[page mode 4]: BGAINPARA1 [default=0x50, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter1 of BGAIN. $BGAINPARA1 = 0.5 + B[6:0]/64$.	0101_0000b

0x50[page mode 4]: BGAINPARA2 [default=0x4C, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter2 of BGAIN. $BGAINPARA2 = 0.5 + B[6:0]/64$.	0100_1100b

0x51[page mode 4]: BGAINPARA3 [default=0x48, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter3 of BGAIN. $BGAINPARA3 = 0.5 + B[6:0]/64$.	0100_1000b

0x52[page mode 4]: BGAINPARA4 [default=0x46, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter4 of BGAIN. $BGAINPARA4 = 0.5 + B[6:0]/64$.	0100_0110b

0x53[page mode 4]: BGAINPARA5 [default=0x44, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter5 of BGAIN. $BGAINPARA5 = 0.5 + B[6:0]/64$.	0100_0100b



0x54[page mode 4]: BGAINPARA6 [default=0x42, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter6 of BGAIN. $BGAINPARA6 = 0.5 + B[6:0]/64$.	0100_0010b

0x55[page mode 4]: BGAINPARA7 [default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter7 of BGAIN. $BGAINPARA7 = 0.5 + B[6:0]/64$.	0100_0000b

0x56[page mode 4]: BGAINPARA8 [default=0x3E, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter8 of BGAIN. $BGAINPARA8 = 0.5 + B[6:0]/64$.	0011_1110b

0x57[page mode 4]: BGAINPARA9 [default=0x3C, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter9 of BGAIN. $BGAINPARA9 = 0.5 + B[6:0]/64$.	0011_1100b

0x58[page mode 4]: BGAINPARA10 [default=0x28, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter10 of BGAIN. $BGAINPARA10 = 0.5 + B[6:0]/64$.	0010_1000b

0x59[page mode 4]: BGAINPARA11 [default=0x26, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter11 of BGAIN. $BGAINPARA11 = 0.5 + B[6:0]/64$.	0010_0110b

0x5A[page mode 4]: BGAINPARA12 [default=0x24, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Parameter12 of BGAIN. $BGAINPARA12 = 0.5 + B[6:0]/64$.	0010_0100b

0x5B[page mode 4]: BGAINBND1 [default=0x44, r/w]

Bit	Function	Description	Default
B[7:4]	AWB	It is marginal range of BGAIN when RGAIN is over RGAINTH1.	0100b
B[3:0]		It is marginal range of BGAIN when RGAIN is under RGAINTH1 and over RGAINTH2	0100b

0x5C[page mode 4]: BGAINBND2 [default=0x44, r/w]

Bit	Function	Description	Default
B[7:4]	AWB	It is marginal range of BGAIN when RGAIN is under RGAINTH2 and over RGAINTH3	0100b
B[3:0]		It is marginal range of BGAIN when RGAIN is under RGAINTH3.	0100b

0x5D[page mode 4]: RGAINTH1 [default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Threshold1 of RGAIN. $RGAINTH1 = 0.5 + B[6:0]/64$. Default is 1.5x	0100_0000b

0x5E[page mode 4]: RGAINTH2 [default=0x30, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Threshold2 of RGAIN. $RGAINTH2 = 0.5 + B[6:0]/64$. Default is 1.25x	0011_0000b



0x5F[page mode 4]: RGAINTH3 [default=0x20, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	Threshold3 of RGAIN. $RGAINTH3 = 0.5 + B[6:0]/64$. Default is 1x	0010_0000b

0x60[page mode 4]: ULVL [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	U chrominance level to converge in AWB.	1000_0000b

0x61[page mode 4]: VLVL [default=0x80, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	V chrominance level to converge in AWB.	1000_0000b

0x66[page mode 4]: MRGAIN [default=0x48, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	When bit[0] AWBCTL2 is enabled, it is used for manual RGAIN in white balance. $MRGAIN = 0.5 + B[6:0]/64$. Default is 1.625x	0100_1000b

0x67[page mode 4]: MBGAIN [default=0x40, r/w]

Bit	Function	Description	Default
B[7:0]	AWB	When bit[0] AWBCTL2 is enabled, it is used for manual BGAIN in white balance. $MBGAIN = 0.5 + B[6:0]/64$. Default is 1.5x	0100_0000b

0xD2[page mode 4]: UAVG [r]

Bit	Function	Description	Default
B[7:0]	AWB	U chrominance of white pixels in frame.	RO

0xD3[page mode 4]: VAVG [r]

Bit	Function	Description	Default
B[7:0]	AWB	V chrominance of white pixels in frame.	RO