SX5433M14X-X0B0
(1/4" VGA CIS Camera Module)

PRELIMINARY

Revision 1.3
May. 2004

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DOCUMENT TITLE

1/4" Optical Size 640x480 (VGA) CIS Camera Module

REVISION HISTORY

| Revision No.	History	Draft Date	Remark
0.0	Initial draft	Oct. 18, 2003	Preliminary
0.1	Added module dimension	Nov. 7, 2003	Preliminary
0.2	I2C timing modified	Nov. 13, 2003	Preliminary
1.0	Specification is released (Changed operating current, min MCLK and storage temperature lower value and added AC characteristics).	Nov. 25, 2003	Preliminary
1.1	Added ESD sensitivity	Nov. 27, 2003	Preliminary
1.2	Changed product code	Jan. 07, 2004	Preliminary
1.3	Stroke out the register map (published a new document, 'Register Map for 433') Modified the optical characteristics	May. 4, 2004	Preliminary

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This document is a general product description and is subject to change without any notice.

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INTRODUCTION

SX5433M14X-X0B0 is a fully functional camera module with a built-in lens. A low-noise low-power color CMOS image sensor, S5K433CA03 and an image signal processor, S5C7322X produce high-quality digital video output in CCIR656 format at maximum 30 frames per second for full frame readout. With SAMSUNG 0.35μm CMOS image sensor process technology which is dedicated to higher sensitivity and lower-dark level compared to standard CMOS process, and on-chip CDS and 10-bit column ADC circuit embedded, the CMOS image sensor provides high signal-to-noise ratio with low power consumption. This compact camera system consists of an image sensor, a signal processor and some passive components packed with IR-cut filter and lens units. The system works with 2.8V single power supply and a clock. All the functions are controlled with control register setting through the standard 2-wire serial interface.

FEATURES

— Optical Size: 1/4 inch

— Unit Pixel: 5.6 μm X 5.6 μm

— Effective Resolution: 640X480, VGA

— 8.5mm X 9.5mm X 6.6mm module size

— 8-bit CCIR656 (YCrCb) Video Output

— VGA Output Capability

— Programmable Gamma Correction

— Auto White Balance and Auto Exposure Control

— Horizontal and/or Vertical Mirror Output

— Standby-Mode for Power Saving

— Maximum 30 Frame per Second

— Single Power Supply Voltage: 2.8V

— I^{2}C Type Control Interface
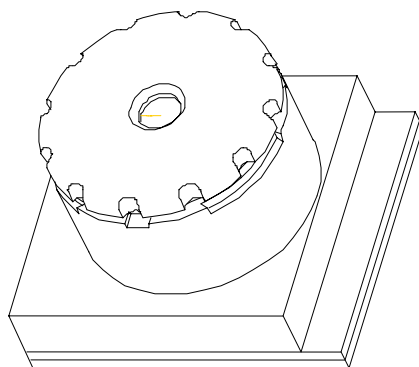
BLOCK DIAGRAM
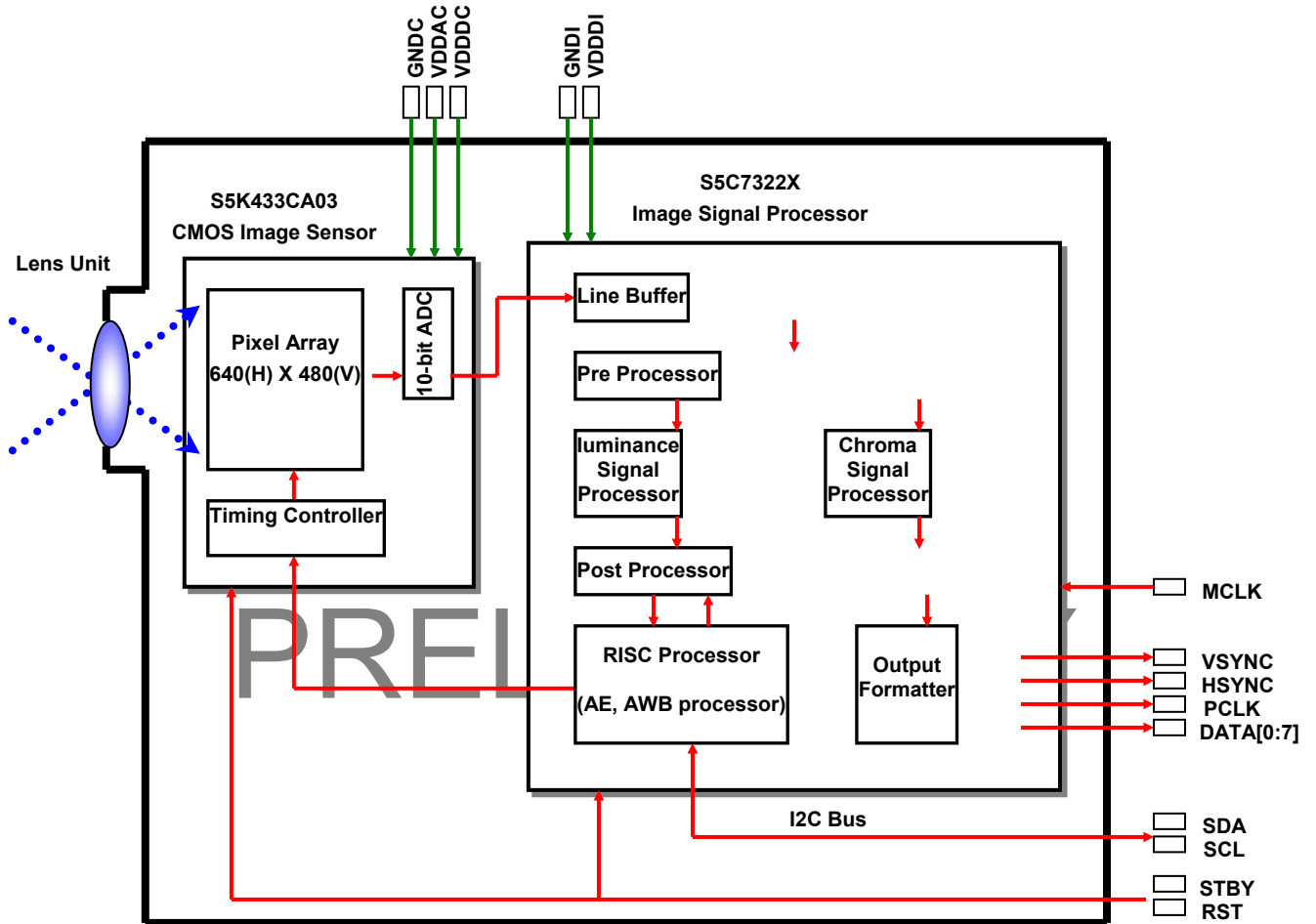
OPTICAL CHARACTERISTICS

Characteristic			Value
Effective Pixels			640 (H) X 480 (V), VGA
Pixel Size			5.6μm (H) X 5.6μm (V), square pixel
EFL			3.385mm
F/#			2.8
FOV		Diagonal	67.87°
		Horizontal	56.44°
		Vertical	43.59°
TV-Distortion			-0.33%
Relative Illumination			54.40%
MTF		Center	59.90% at 80 lp/mm
			72.60% at 50 lp/mm
		0.7 Field	21.30% at 80 lp/mm
			42.30% at 50 lp/mm
Lens Construction			All Plastic Lens (2P)
Focus Range			22cm ~ ∞

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IO PIN DESCRIPTION

(Connector type and pin numbers can be changed as customer's request.)

Module Pad	Connector Pin	Pin Name	Type	Notation
1	9	VDDDI	Power	Power supply for signal processor (digital)
2	10	GNDI	Ground	Ground for signal processor
3	15	SCL	In / Out	I^2C serial communication clock
4	16	SDA	In / Out	I^2C serial communication data
5	11	RST	In	Reset control (active low)
6	12	STBY	In	Standby mode control (active low)
7	20	MCLK	In	Master input clock
8	17	VSYNC	Out	Vertical synchronization clock
9	18	HSYNC	Out	Horizontal synchronization clock
10	19	PCLK	Out	Pixel output clock
11	8	DATA0	Out	8-bit digital video output
12	7	DATA1	Out	
13	6	DATA2	Out	
14	5	DATA3	Out	
15	4	DATA4	Out	
16	3	DATA5	Out	
17	2	DATA6	Out	
18	1	DATA7	Out	
19	13	GNDC	Ground	Ground for sensor circuit block
20	9	VDDCD	Power	Power supply for sensor digital circuit block
21	14	VDDCA	Power	Power supply for sensor analog circuit block

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MAXIMUM ABSOLUTE RATINGS

Characteristic	Symbol	Rating	Unit
Maximum supply voltage (VDDDI, VDDAC, VDDC supply relative to GNDI, GNDC)	V_{DD}	-0.3 to 3.8	V
DC Input voltage	V_{IN}	-0.3 to V_{DD}+0.3 (Max. 3.8)	
Operating temperature	T_{OPR}	-20 to +60	°C
Storage temperature	T_{STG}	-40 to +85	

ELECTRICAL CHARACTERISTICS

DC Characteristics

(T_A = -20 to +60°C, C_L = 15pF)

Characteristics	Symbol	Condition	Min	Typ	Max	Unit
Operating voltage	V_{DD}	VDDDI, VDDAC, VDDC	2.55	2.8	3.05	V
Input voltage [1]	V_{IH}	-	2.0	-	-	V
	V_{IL}	-	-	-	0.8	
Input leakage current [1]	I_{IL}	V_{IN} = V_{DD} to V_{SS}	-10	-	10	μA
High Level Output voltage	V_{OH}	I_{OH} = -4mA [2]	$0.8V_{DD}$	-	-	V
		I_{OH} = -8mA [3]				
Low Level Output voltage	V_{OL}	I_{OL} = 4mA [2]	-	-	$0.2V_{DD}$	
		I_{OL} = 8mA [3]				
High-Z output leakage current [4]	I_{OZ}	V_{OUT} = V_{DD}	-	-	10	μA
Supply current	I_{STB}	STBYN = Low (active) All input clocks = Low	-	15	-	μA
	I_{DD}	f_{MCLK} = 13.5MHz, 15 fps	-	31	36	mA

NOTES:
1. MCLK, RST, STBY, SCL, and SDA pin.
2. HSYNC, VSYNC, SCL, and SDA pin
3. PCLK, DATA0 to DATA7 pin
4. SCL and SDA pin when in High-Z output state

Sensor Imaging Characteristics

(Light source with 3200K of color temperature and IR cut filter (CM-500S, 1mm thickness) is used. Electrical operating conditions follow the recommended typical values. The control registers are set to the default values. The ambient temperature, T_A is 25°C if not specified.)

Characteristic	Symbol	Condition	Min	Typ	Max	Unit
Saturation level[1]	V_{SAT}		850	900	-	mV
Sensitivity (G)[2]	S		-	2000	-	mV/lux sec
Dark level[3]	V_{DARK}	$T_A = 40°C$	-	9	18	mV/sec
		$T_A = 60°C$	-	50	100	
Dynamic range[4]	DR		-	60	-	dB
Signal to noise ratio[5]	S/N		-	40	-	
Dark signal non-uniformity[6]	DSNU	$T_A = 60°C$	-	-	100	mV/sec
Photo response non-uniformity[7]	PRNU		-	4	8	%
Vertical fixed pattern noise[8]	VFPN			4	8	%
Horizontal fixed pattern noise[9]	HFPN			4	8	%

NOTES:

1. Measured minimum output level at 100lux illumination for exposure time 1/30 sec. 7X7 rank filter is applied for the whole pixel area to eliminate the values from defective pixels.
2. Measured average output at 25% of saturation level illumination for exposure time 1/30 sec. Green channel output values are used for color version.
3. Measured average output at zero illumination without any offset compensation for exposure time 1/30 sec.
4. 20 log (saturation level/ dark level RMS noise excluding fixed pattern noise). 10-bit ADC limits 60dB.
5. 20 log (average output level/RMS noise excluding fixed pattern noise) at 25% of saturation level illumination for exposure time 1/30 sec.
6. Difference between maximum and minimum pixel output levels at zero illumination for exposure time 1/30 sec. 7X7 median filter is applied for the whole pixel area to eliminate the values from defective pixels.
7, Difference between maximum and minimum pixel output levels divided by average output level at 25% of saturation level illumination for exposure time 1/30 sec. 7X7 median filter is applied for the whole pixel area to eliminate the values from defective pixels.
8. For the column-averaged pixel output values, maximum relative deviation of values from 7-depth median filtered values for neighboring 7 columns at 25% of saturation level illumination for exposure time 1/30 sec.
9. For the row-averaged pixel output values, maximum relative deviation of values from 7-depth median filtered values for neighboring 7 columns at 25% of saturation level illumination for exposure time 1/30 sec.

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AC Characteristics

(V_{DD} = 2.55V to 3.05V, Ta = -20 to + 60 °C)

Characteristic	Symbol	Condition	Min	Typ	Max	Unit
Main input clock frequency	f_{MCLK}	Duty = 50%	5	24.54	30	MHz

(V_{DDH} = 2.8V ± 0.25, T_a = 0 to + 70 °C)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Data Delay Time, Data [0:7]	T_{DLY}	0.5	-	3	ns
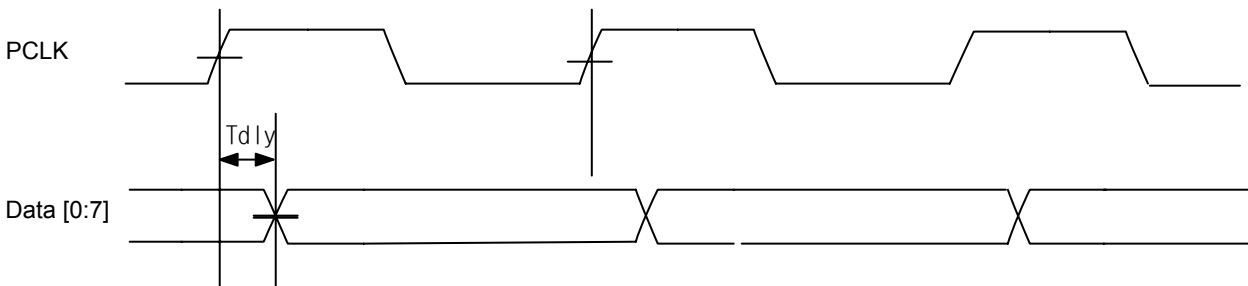
Setup and Hold Time

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(V_{DDL} = 1.8V ± 0.15, T_a = 0 to + 70 °C, C_L = 0.011pF)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Data Setup Time, Data [0:7]	T_{SU}	0.217	-	-	ns
Output Data Hold Time, Data [0:7]	T_{HD}	0.217	-	-	ns
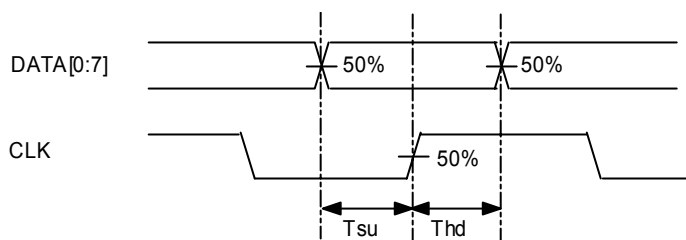
Rise and Fall Transition Time

(V_{DDL} = 1.8V ± 0.15, T_a = 0 to + 70 °C, C_L = 0.011pF)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Data, Data [0:7]	T_R	-	-	4.709	ns
	T_F	-	-	4.338	ns
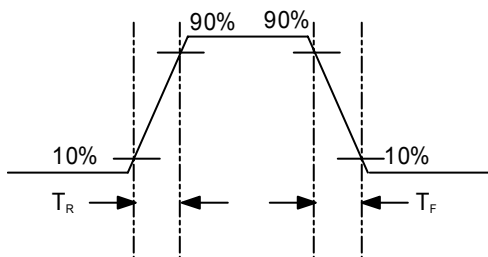
ESD Sensitivity

(CMOS Image Sensor IC)

Item	Condition	Result
Human Body Model (HBM)	C = 100 pF, R = 1.5KΩ	±1500V↑
Machine Model (MM)	C = 200 pF, R = 0Ω	±200V↑
Charged Device Model (CDM)		±800V↑

(Image Signal Processor IC)

Item	Condition	Result
Human Body Model (HBM)	C = 100 pF, R = 1.5KΩ	±2000V↑
Machine Model (MM)	C = 200 pF, R = 0Ω	±200V↑
Charged Device Model (CDM)		±500V↑

OUTPUT IMAGE MODE

No.	Mode	Resolution (H X V)
1	VGA	640X480
2	QVGA	320X240
3	QQVGA	160X120

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OUTPUT DATA FORMAT
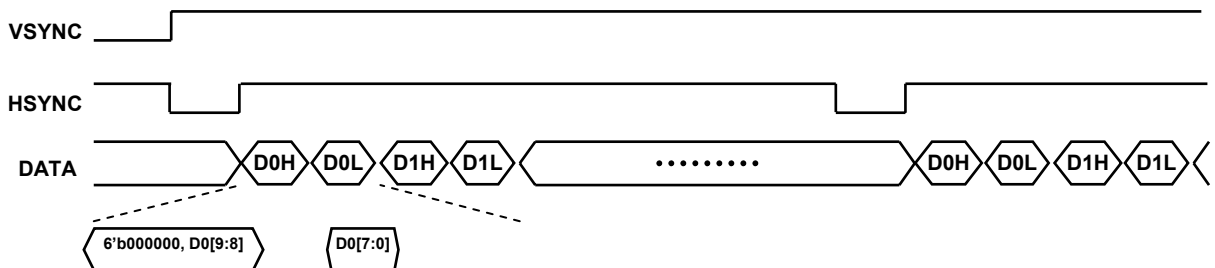
YC$_R$C$_B$ 4:2:2 FORMAT

RGB565 FORMAT
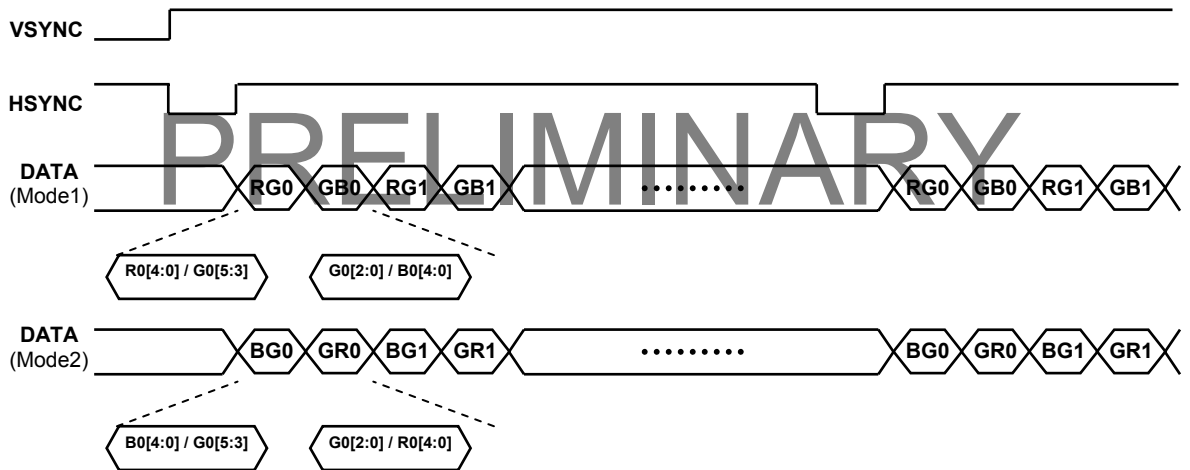
SENSOR RAW IMAGE (BAYER MOSAIC PATTERN) FORMAT

OUTPUT TIMING DIAGRAMS

HORIZONTAL TIMING

Address : FAh[7:6]=0, F6h[7:0]=30   Address : FAh[5:4]=2, F7h[7:0]=B0

1 row

HSYNC

PCLK

(640 columns)

DATA [0:7]

VGA OUTPUT TIMING

Address : FAh[3:2]=0, F8h[7:0]=03   Address : FAh[1:0]=0, F9h[7:0]=05   2H

1 frame

VSYNC

1 row

HSYNC

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DATA [0:7]

(480 rows)

(525 rows)
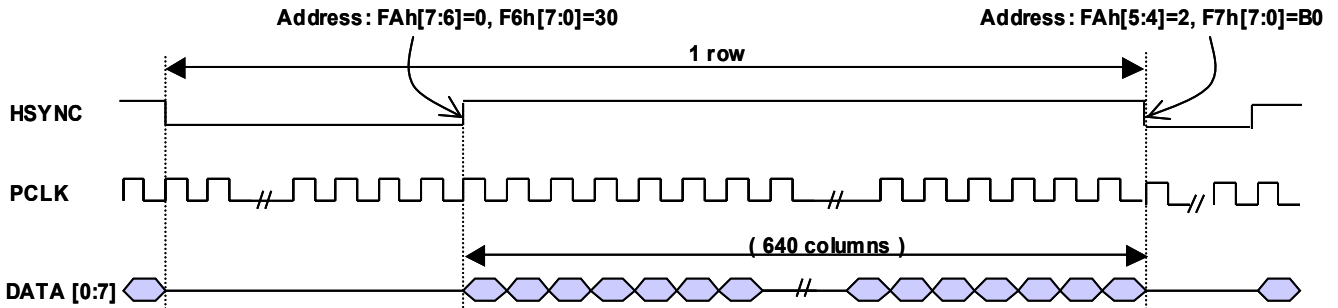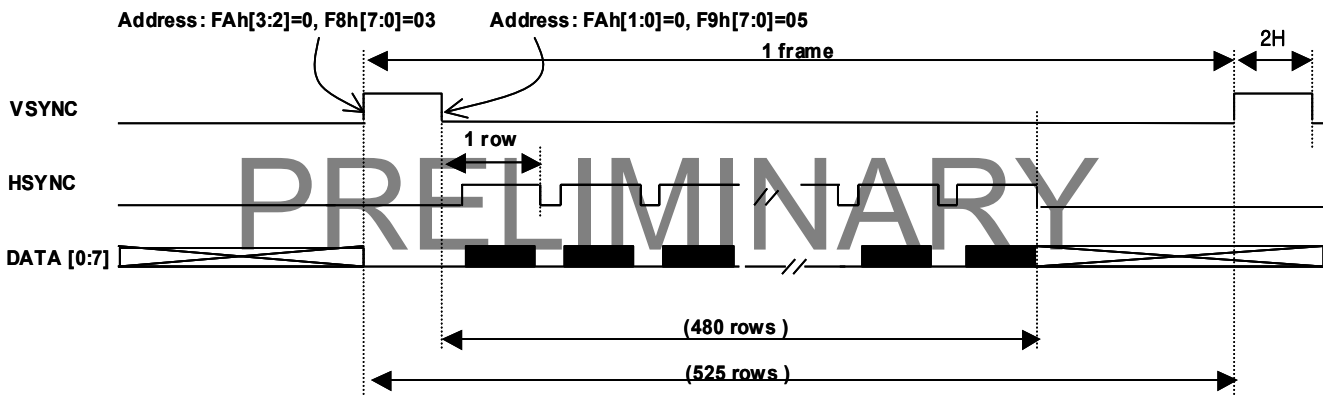
NOTES:

1. Falling and rising time of HSYNC and VSYNC can be controlled by register settings.
2. Each default value of rising and falling time control registers is described in the diagram above.

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IMAGE PROCESSING FUNCTIONS

Function	Description	Remarks
Defect detection and correction	If enabled, the function detects the defective pixel by comparing its level with horizontally neighboring pixels, and replaces it with the average value of neighboring pixels.	
De-mosaic	The sensor produces one color component from a pixel according to Bayer color filter array. The de-mosaic function performs color interpolation to produce all three-color components at each pixel location.	
Color correction	The spectral response of image sensor is different from that of human eye. To match the spectral response, the sensor output components are pivoted by user programmable 3X3 matrix production.	
Gamma correction	Gamma correction translating the linear response of the sensor into the non-linear characteristics of the display. Non-linear conversion requires a piecewise linear approximation method based on user programmable lookup table.	
Horizontal mirror	The output image can be mirrored in horizontal direction.	
Vertical mirror	The output image can be mirrored in vertical direction.	
Edge enhancement	Enhancing the edge component provides a clear output image. The edge enhancement function is performed through horizontal and vertical edge detecting and enhancing.	
Auto exposure	According to the incident light level, the auto exposure function controls the sensor gain and effective integration time to maintain the proper output level. Setting the control registers can change the sensing area used in the AE algorithm.	
Auto white balance	The auto white balance function adjusts the gain of the sensor's red and blue channels relative to the green channel, and compensates the spectral unbalancing of the light source. Setting the control registers can change the sensing area used in the AWB algorithm.	
Output format conversion	4 types of output format are available. (CCIR656 format, CCIR601 format, RGB format and sensor raw image output format)	
Sub-sampling Control	The user can read out the pixel data in sub-sampling rate in both horizontal and vertical direction. Sub-sampling can be done in two rates: full and 1/2. The user controls the sub-sampling using the Sub-sampling Control Registers, **subsr** and **subsc**. The sub-sampling is performed only in the Bayer space.	

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I²C SERIAL INTERFACE

The I²C contains a serial two-wire half duplex interface that features bi-directional operation, master or slave mode. The general **SDA** and **SCL** are the bi-directional data and clock pins, respectively. These pins are open-drain type ports and will require a pull-up resistor to VDD. The image sensor operates in salve mode only and the **SCL** is input only. The I²C bus interface is composed of following parts: START signal, 7-bit slave device address (0101101Xb) transmission followed by a read/write bit, an acknowledgement signal from the slave, 8-bit data transfer followed by an acknowledgement signal and STOP signal. The **SDA** bus line may only be changed while **SCL** is low. The data on the **SDA** bus line is valid on the high-to-low transition of **SCL**.
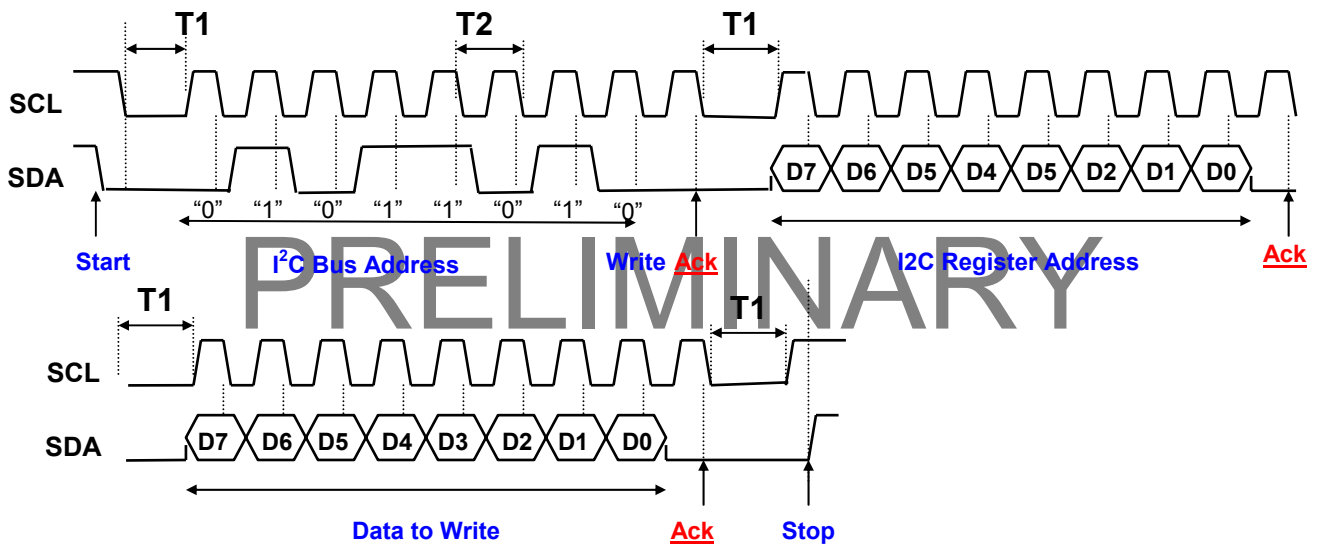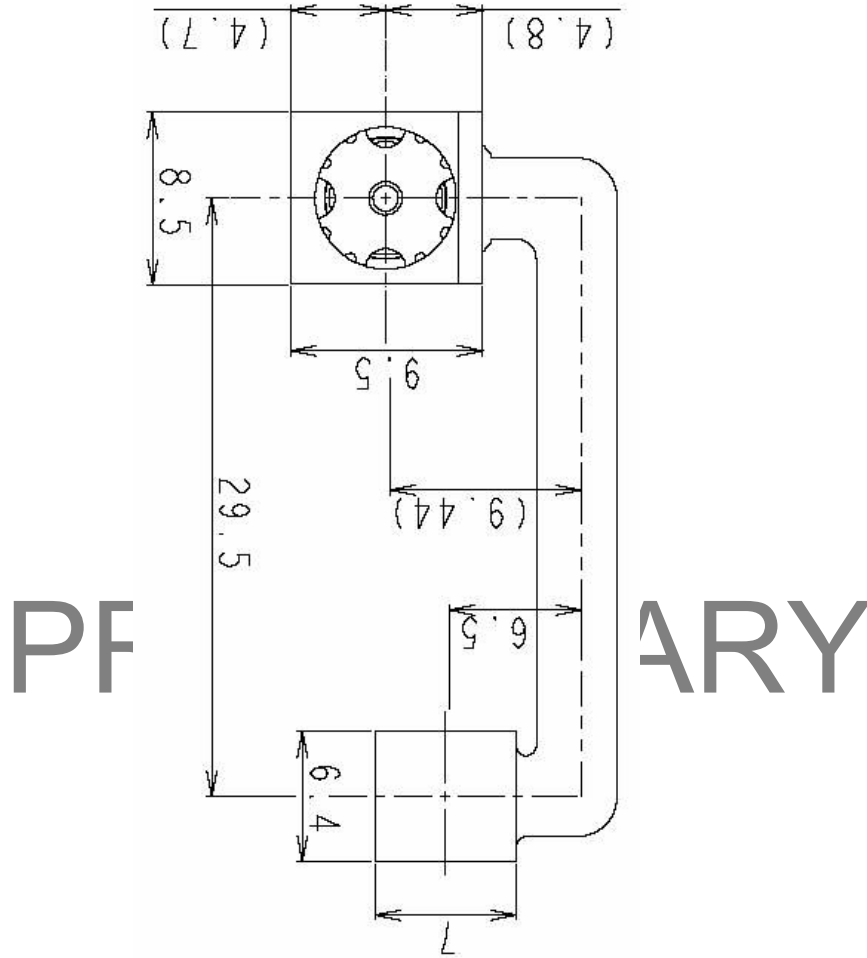

I²C Bus Write Cycle

I²C Bus Read Cycle
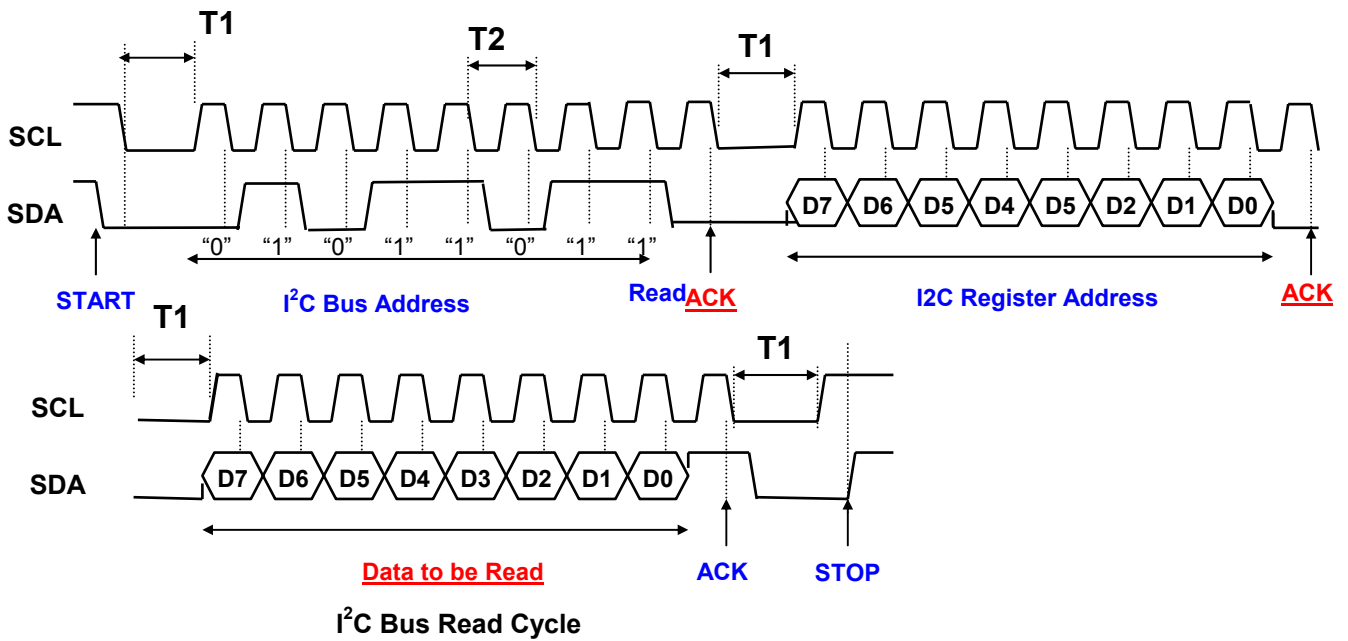
Main Clock - 13.5MHz

Characteristic	Symbol	Min	Typ	Max	Unit
Low period of SCL clock	T1	13.5	15	-	μsec
Clock period	T2	13.5	15	-	μsec
Bus free time between a STOP and START condition	T_{BUF}	100		-	μsec

NOTES:

1. The basic frequency of main clock is 13.5MHz for all the followed comments.

2. If you don't have ACK signal on the way of communications through I²C, it means that I²C error is generated.

3. If you have any I²C error, try again after 2VSYNC (The I²C error is reset every 2VSYNC automatically).

4. If any error is not generated till one command is completed, you can transfer another after 4msec

5. The time value of T1, T2, T3, and T_{BUF} is proportional to the change of MCLK.

6. I²C Bus read format is different from I²C standard format.

MECHANICAL DIMENSION (UNIT = MM)

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