1/10-Inch 0.3 Mega Pixel Image Sensor
SP0A29

Specification

Version Commercial 1.2

2013.07.05

SuperPix Micro Technology Co., Ltd

1/10-Inch 0.3 Mega Pixel Image Sensor Part Number SP0A29

The 1/10 inch 0.3-megapixel color image sensor SP0A29 is the upgrade version of SuperPix® SP0AXX series products that has been widely used in mobile phone and tablet computer markets. With plenty of sophisticated functionalities, SP0A29 can capture both video and single images and becomes a perfect choice for portable equipment. The SP0A29 consists of 640 x 480 effective pixels, low power analog signal processing circuits (ASP), improved image signal processor (ISP), parallel and MIPI data output interface. Based on SuperPix®'s the 2nd ISP algorithms, the image performance such as white balance, image sharpness, exposure control, and de-noise are greatly improved. Compared with similar products, SP0A29 shows better cost performance. SP0A29 supports high frame speed up to 30fps @ 640 x 480 (VGA) resolution through a 1-line MIPI interface or a traditional high speed parallel interface.

Functionalities

- CMOS Image Sensor
- Image Signal Processor
- MIPI Serial Interface
- Parallel Interface

Applications

- Mobile Phone Camera
- Tablet Build-in Camera
- Notebook PC Camera
- PC Camera
- Web Camera

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Overview

General Description

SuperPix® SP0A29 is an advanced 1/10 inch, 0.3 mega pixel color image sensor chip with a sophisticated image signal processor (ISP) functionality and the latest MIPI interface - Mobile Industry Processor Interface. SP0A29 produces extraordinarily refined digital pictures, and its ability to capture both video and single images makes it the perfect choice for a wide range of mainstream consumer applications. SP0A29 can output image data through MIPI interface, which is the most important data transport path for the next generation smart phone and makes SP0A29 capable of various products. In addition the SP0A29 is based on the SuperPix® 2nd generation CMOS image sensor technology and is the upgrade edition of SuperPix® SP0AXX series products. The recommendable low stack height, high speed interface, and high quality images will make it become a critical role for handset market.

SuperPix® always tries to enhance its image sensor technology and SP0A29 is designed specifically to meet the demands of the rapidly growing handset market. Plenty of advanced features enable the SP0A29 to become the best-in-class 0.3 mega CMOS sensor. The processing functions of SP0A29 include all standard and advanced functions, for instance, advanced auto white balance, refined image sharpen and de-noise function, bad pixel calibration based on improved algorithm, advanced auto exposure control, and so forth. Further more, with high performance MIPI interface SP0A29 consumes much less power and continued output high definition images. SP0A29 supports high frame speed up to 30fps @ 640 x 480 (VGA) resolution transferred over a one line MIPI interface or a traditional high speed parallel interface.

An overview of the SP0A29 Image Sensor features and functions will be given below.

Function Diagram

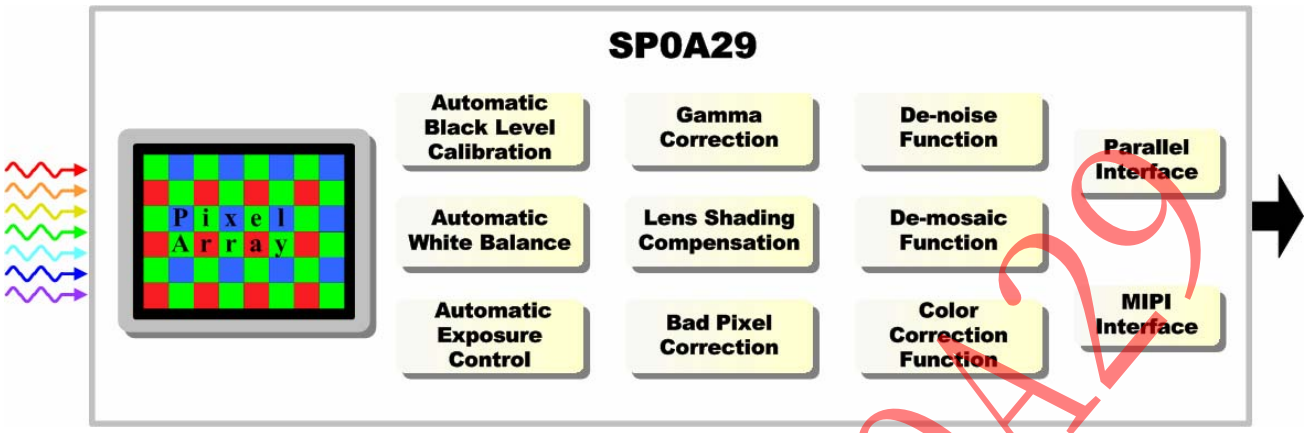


Figure 1 Function Diagram

Typical Application List

- Mobile Phone Camera
- Tablet Build-in Camera
- Notebook PC Camera
- PC Camera
- Web Camera

Typical Application Diagram

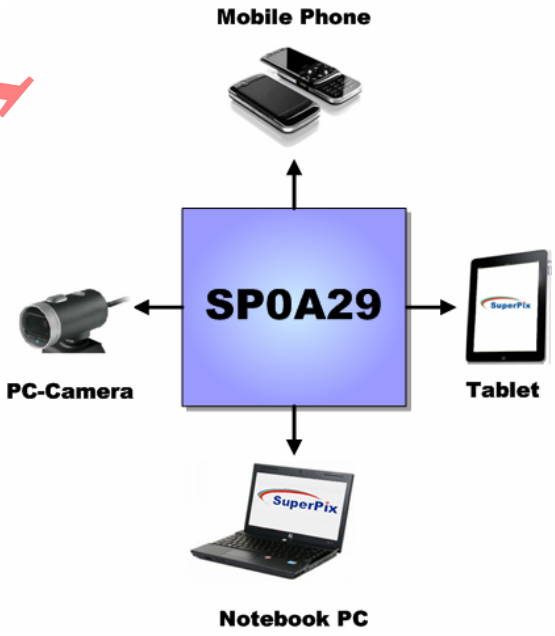


Figure 2 Typical Application

Key Performance Parameters

Parameter	Value
Active Pixel Array	640 x 480
Pixel Size	2.2um x 2.2um Square Pixel
Lens Size	1/10 inch
Color Filter	Primary Color Filter Bayer arrangement
Power Supply	I/O 1.7V ~ 3.0V
	Analog 2.6V ~ 3.0V
Power Consumption	Active TBD
	Standby 15uA
Data Formats	Raw Bayer Format
	YUV422
Output Formats	CSI-2 1lane
	8bit Parallel
Input Clock	6 – 30 MHz
Max. Frame Rate	30fps@VGA Mode
Operating Temperature	-20°C ~ 70°C
Stable Temperature	0°C ~ 50°C
Package	COB / TSV

Table 1 Key Performance Parameters

Features List

- Support VGA (0.3Mega 640x480) resolution
- Advanced 2.2um x 2.2um pixel architecture
- Embedded image preprocessor functionality
  - Automatic Black Level Calibration
  - Automatic White Balance
  - Automatic Exposure Control
  - Gamma Correction
  - Lens Shading Compensation
  - De-mosaic Function
  - De-noise Function
  - Color Correction Function
  - Bad Pixel Correction
  - Special Effect: Sepia, Monochrome, Emboss, Sketch, Neon, Grey, Solarize, Posteraize, Enchase
- I^2C bus controlling registers inside chip
- Support high precision VFPN circuit
- Support high speed parallel output interface
- Support MIPI (CSI-2) interface

Function Description

Pixel Array Structure

The SP0A29 pixel array is configured as of 676 columns by 500 rows, shown below.

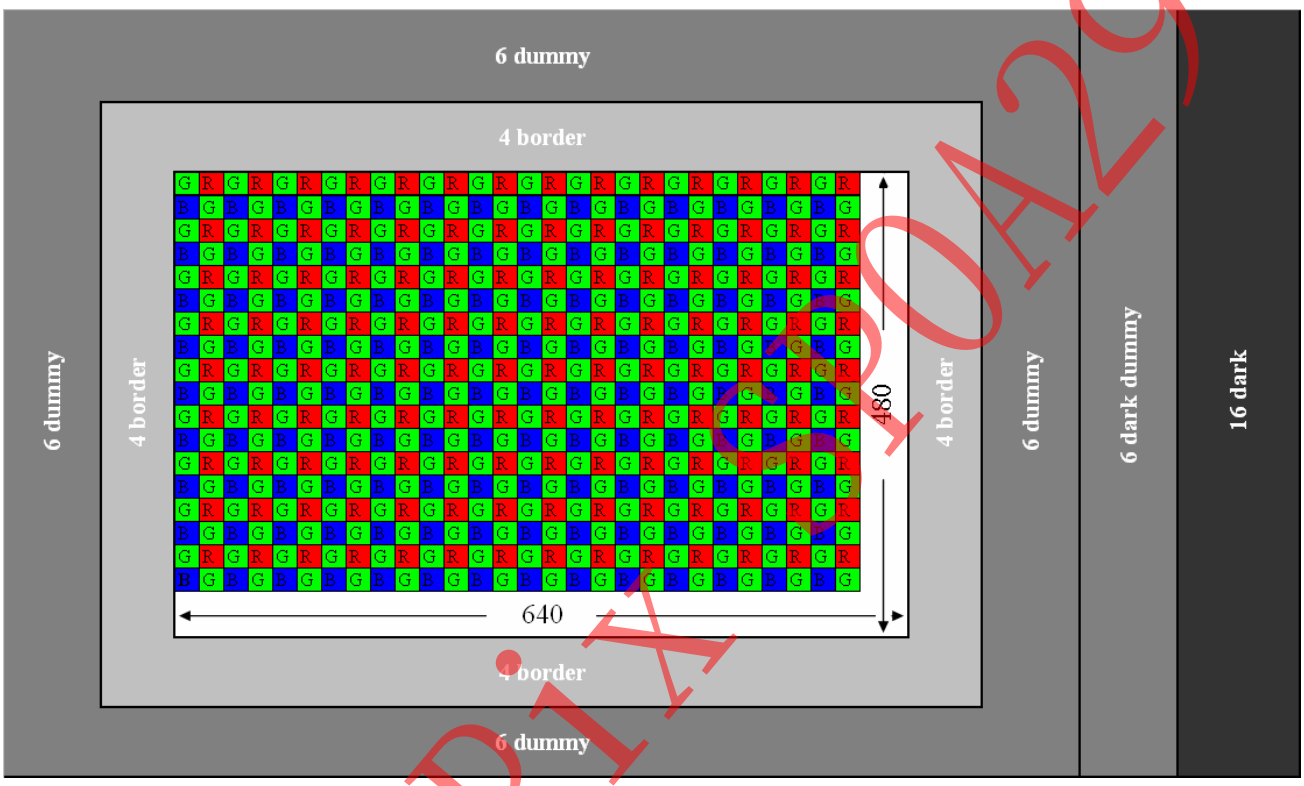


Figure 3 Pixel Floor Plan

Note:
The color filter of the first pixel at left bottom is blue.

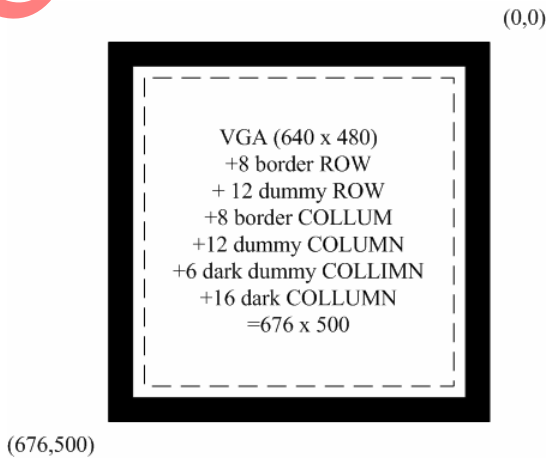


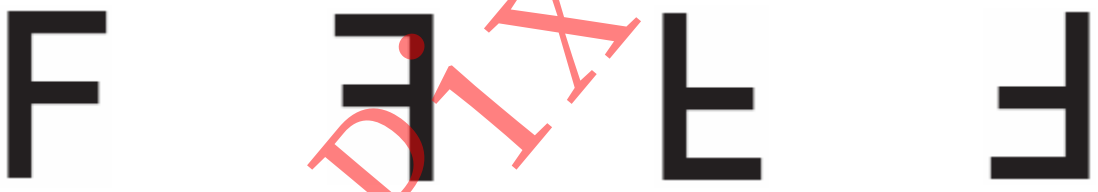
Figure 4 Sensor Pixel Description

Image Signal Process

- Mirror and Flip
- Test Pattern
- Automatic Black Level Calibration
- Automatic White Balance
- Automatic Exposure Control
- Gamma Correction
- Lens Shading Compensation
- Demosaic Function
- Denoise Function
- Color Correction Function
- RGB to YUV Conversion
- Special Effect

Mirror and Flip

Mirror and Flip read out modes are provided, and can reverse the sensor data read out order horizontally and vertically respectively.



Original Mirrored Flipped Mirrored and Flipped

Figure 5 Mirror and Flip

Test Pattern

Test pattern, color bar, is offered for testing purpose.

Automatic Black Level Calibration

The pixel array contains several optically black lines, which can be seen at the pixel array structure section. These lines are used to provide the data for black level calibration and further correction.

Automatic White Balance

Auto white balance unit is help to remove the unrealistic color from the image automatically by referencing the white balance pre-gain. With auto white balance unit, the still / video camera system can determine the color temperature of the light and automatically adjust for the color temperature.

Automatic Exposure Control

After Gamma unit, the Y value, calculated by R, G, and B values, used to evaluate the luminance and exposure time, digital gain, analog gain are adjusted by this block to get the right luminance for the image.

Gamma Correction

The main purposed of the Gamma correction function is to compensate the characteristics of the sensor. According to de gamma curve, the pixel values can be converted in order to compensate the sensor output on different light strength conditions.

Lens Shading Compensation

Lens imperfection can be eliminated by lens shading compensation. It starts with the first pixel of a frame when the lens shading compensation unit is enabled, and correcting each pixel with its gain values.

The lens shading correction is based on one or more reference frames which have to be captured under dedicated light conditions and a dedicated position of the sensor. The pixels of the captured frame are then evaluated by software and the calculated parameters for lens shading correction are stored in different tables. It is also possible to use different lens shading correction parameters for different environment conditions. Therefore additional reference frames for the different conditions are to be captured and evaluated. The calculated parameters including sector settings can be stored in multiple tables.

Demosaic Function

De-mosaic function is to convert the raw data to RGB image data. The algorithm is a digital image process used to interpolate a complete image from the partial raw data

received form the color filter in form of a matrix of colored pixels. Each raw pixel data is converted to RGB value using an edge-sensitive color interpolation algorithm.

Denoise Function

The denoise function can reduce the noise existing on edges markedly and smooth the shades.

Color Correction Function

The color correction function is including various color profiles that are used for color representation improvement. The function works by making decision based on scene brightness and illumination type.

Bad Pixel Correction

Bad pixels will be detected and be replaced by a value calculated from the neighbor pixel during the Bad Pixel Correction unit. A bad pixel is a pixel which is black, and is not charged when light hits it, a zero value is read. Such bad pixels will be detected and corrected.

RGB to YUV Conversion

It is used to convert the RGB color space to YUV color space so that the following image processing can be done in the YUV color space.

Special Effect

A set of image special effect is supported, which includes sepia, monochrome, emboss, sketch, neon, grey, solarize, posteraize, and enchase.

Output Interface

- MIPI Interface
- Parallel Interface

Both MIPI data output interface and parallel data output interface integrated inside the sensor chip.

MIPI Serial Interface

MIPI Serial Interface – Mobile Industry Processor Interface is the most important data transport path for the next generation mobile phone, which defines standards for the interface between SP0A29 modules of a mobile. The MIPI interface can support large data stream better than any other data interface. With it SP0A29 can provide more high definition images to the mobile phone.

MIPI inside SP0A29 provides one single uni-directional clock lane and one bi-directional data lane solution for communication links between components inside a mobile device. Data lane has full support for HS and LP data transfer mode.

I²C Bus

Single READ and Single WRITE

A typical READ or WRITE sequence begins by the master sending a start bit. After the start bit, the master sends the slave device's 8-bit address. The last bit of the address determines if the request will be a read or a write, where a 0 indicates a WRITE and a 1 indicates a READ. The slave device acknowledges its address by sending an acknowledge bit back to the master.

The write device address is 42H and the read device address is 43H. And it is markedly that the device address of SP0A29 is programmable.

If the request was a WRITE, the master then transfers the 8-bit register address to which a write should take place. The slave sends an acknowledge bit to indicate that the register address has been received. The master then transfers the data 8 bits at a time, with the slave sending an acknowledge bit after each 8 bits. The master stops writing by sending a start or stop bit.

A typical READ sequence is executed as follows. First the master sends the write-mode slave address and 8-bit register address just as in the write request. The master then sends a start bit and the read-mode slave address. The master then clocks out the register data 8 bits at a time. The master sends an acknowledge bit after each 8-bit transfer. The data transfer is stopped when the master sends a no-acknowledge

bit.

Tow figures that is shown below will illustrate SP0A29 single READ sequence and single WRITE sequence.

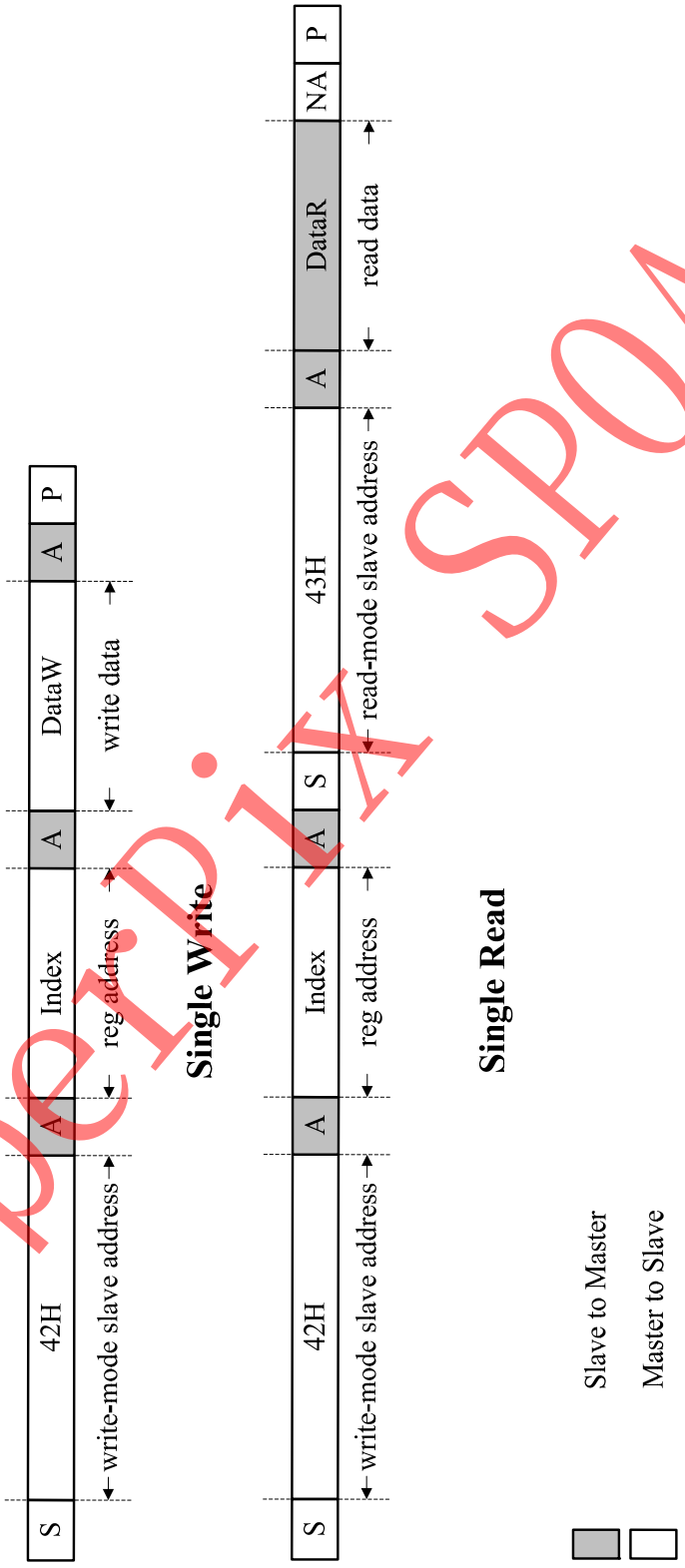


Figure 6 I²C Read & Write Description

Start/Stop Conditions

The serial bus will recognize logic 1 to logic 0 transition on the SDA pin while the SCLK pin is at logic 1 as the start condition. A logic 0 to logic 1 transition on the SDA pin while the SCLK pin is at logic 1 is interrupted as the stop condition.

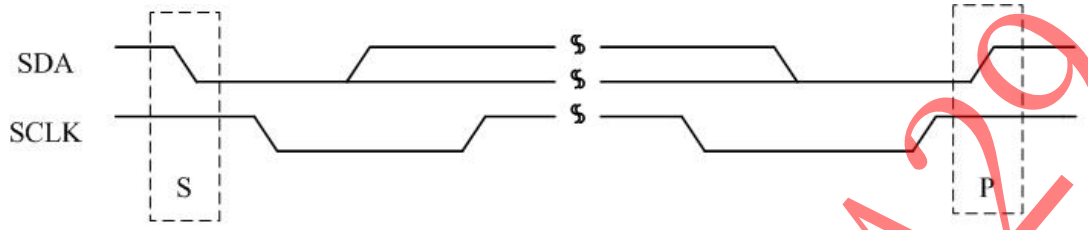


Figure 7 I²C Start & Stop Description

Acknowledge Bit

The SP0A29 will hold the value of the SDA pin to logic 0 during the logic 1 state of the Acknowledge clock pulse on SCLK.

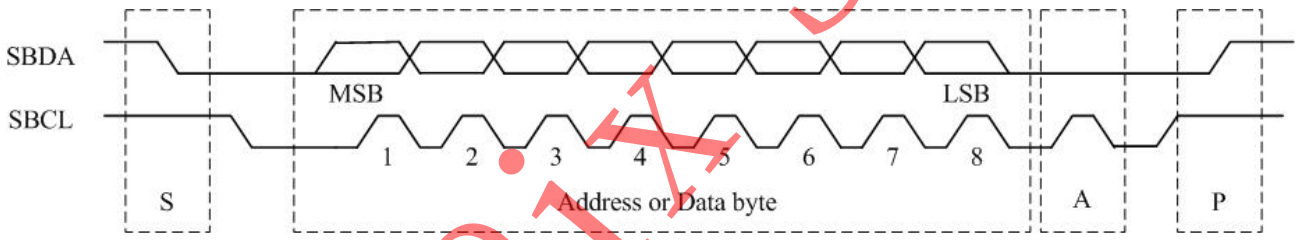


Figure 8 I²C Acknowledge Bit Description

Data Valid

The master must ensure that data is stable during the logic 1 state of the SCLK pin. All transitions on the SDA pin can only occur when the logic level on the SCLK pin is “0”.

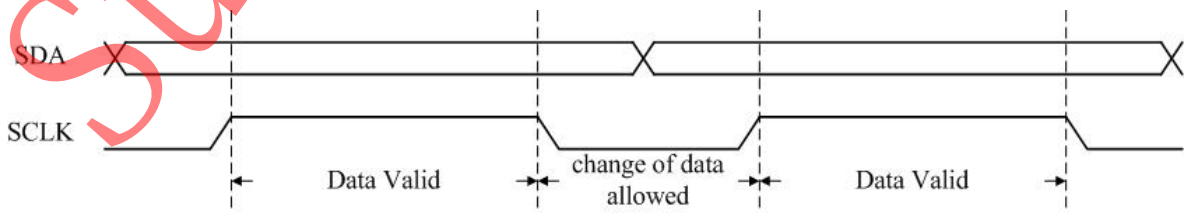


Figure 9 I²C Data Transport Description

Timing Parameter

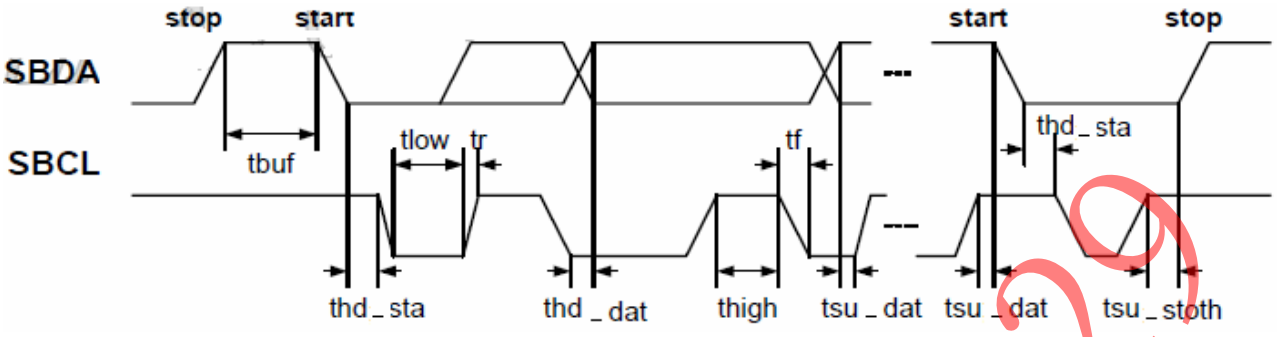


Figure 10 I²C Bus Timing Parameter Illustration

Symbol	Description	Min	Max	Unit
fscl	SBCL clock frequency	10	400	KHz
tbuf	Bus free time between a stop and a start	1.2	-	ns
thd_sta	Hold time for a repeated start	1	-	ns
tlow	LOW period of SBCL	1.2	-	ns
thigh	HIGH period of SBCL	1	-	ns
tsu_sta	Setup time for a repeated start	1.2	-	ns
thd_dat	Data hold time	1.3	-	ns
tsu_dat	Data Setup time	250	-	ns
tr	Rise time of SBCL, SBDA	-	250	ns
tf	Fall time of SBCL, SBDA	-	300	ns
tsu_sto	Setup time for a stop	1.2	-	ns
Cb	Capacitive load of bus line (SBCL, SBDA)	-	-	pf

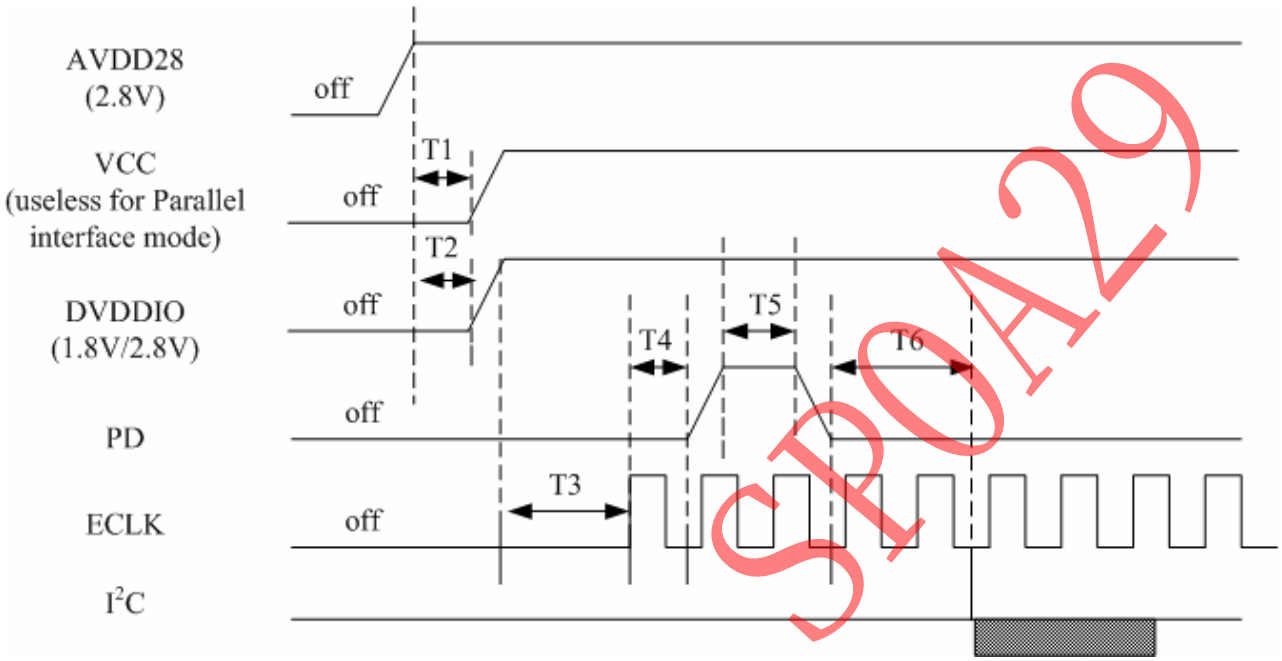
Electric Characteristics

DC Specifications

Symbol	Description	Min.	Typ.	Max.	Unit
AVDD	Power supply voltage for IO and analog	2.6	2.8	3.0	V
VDDIO	Power supply voltage for IO and digital	2.6	2.8	3.0	V
		1.7	1.8	2.0	V
VIH	Input high Voltage	0.7xVDDIO		3.0	V
VIL	Input low voltage	0		0.3xVDDIO	V
VOH	Output high voltage@8mA	0.7xVDDIO			V
VOL	Output low voltage@8mA			0.3xVDDIO	V
T	Junction Temperature	-20	25	70	**°C**

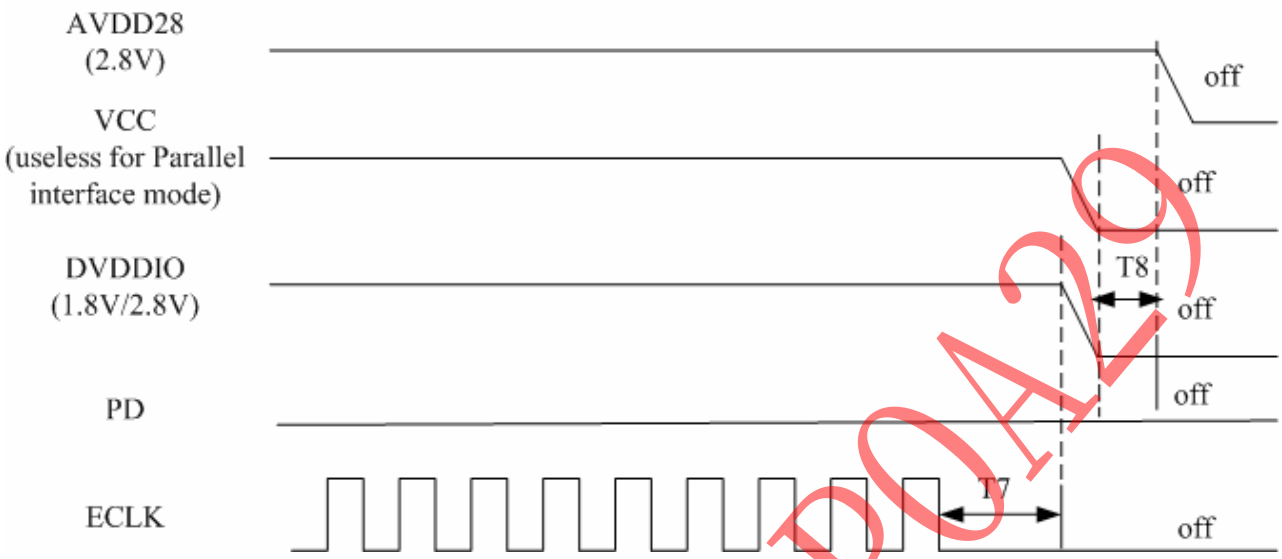
Power Up/Off Sequence

Power Up Chart



Symbol	Description	Min.	Unit
T1	Time from AVDD28 to VCC	0	ms
T2	Time from AVDD28 to DVDDIO	0	ms
T3	Time from DVDDIO to clock plus input	0	ms
T4	Time from clock plus input to PD up edge	0	ms
T5	PD high plus time	100	ns
T6	Time from PD down edge to available I^2C	5	ms

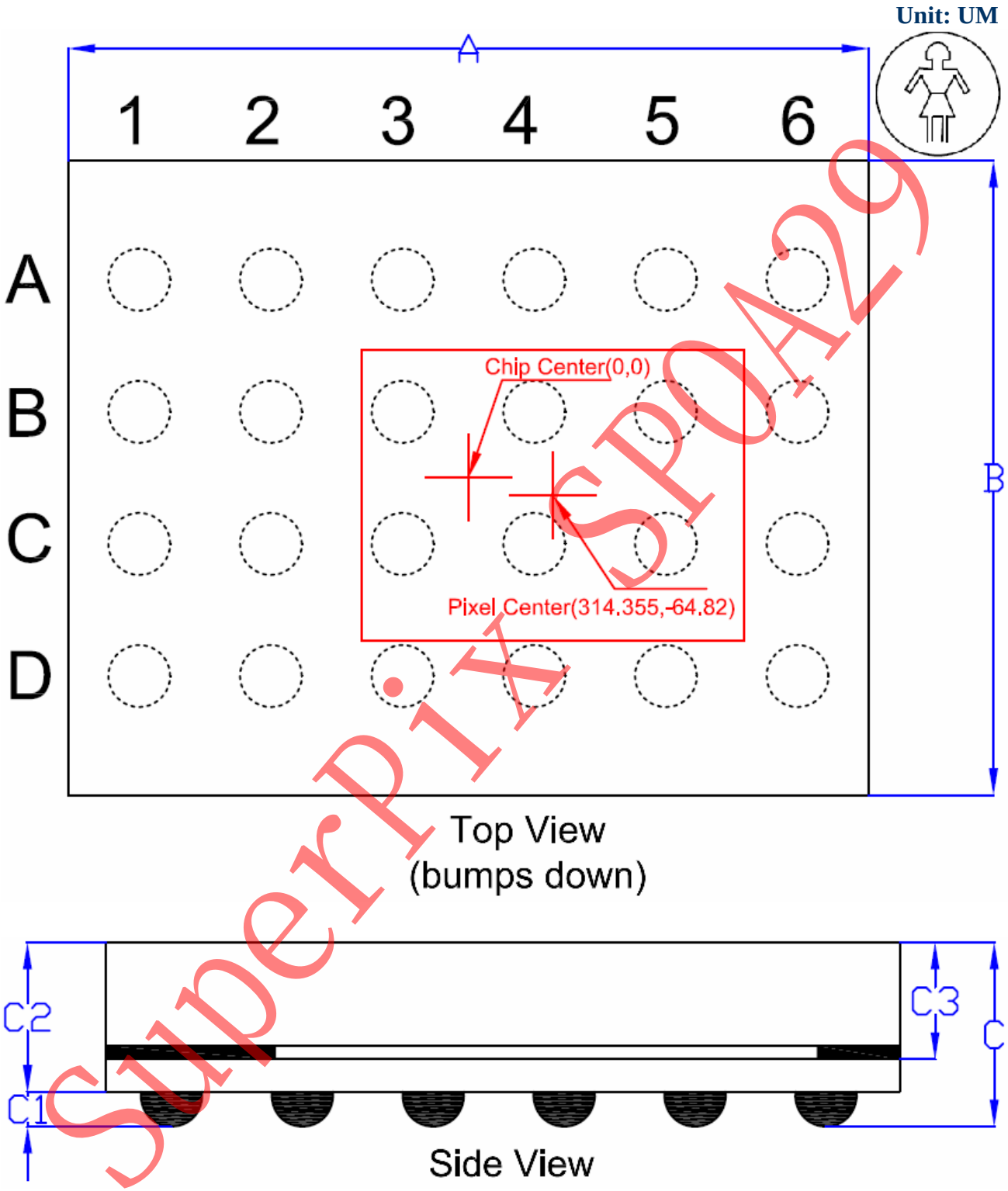
Power Off Chart

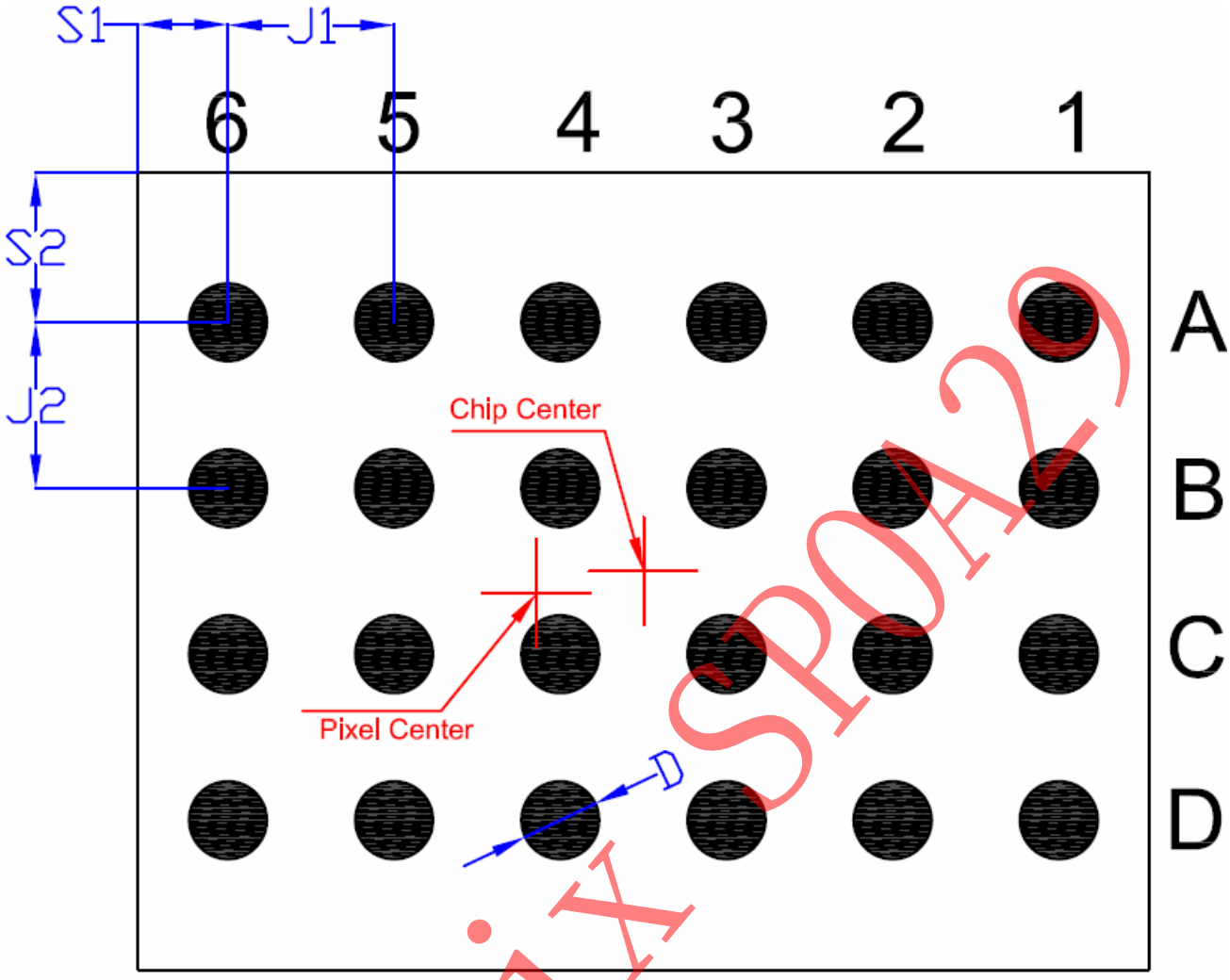


Symbol	Description	Min.	Unit
T7	Time from clock plus stop to DVDDIO and VCC power down	0	ms
T8	Time from DVDDIO and VDD to AVDD28 power down	0	ms

Package

Unit: UM





Bottom View
(Bumps up)

Pin Location	1	2	3	4	5	6
A	D0M	CKP	VCC	ECLK	PCLK	SBDA
B	D0P	CKM	VSS	PWDN	HSYNC	VSYNC
C	D1	D2	D4	DVDD	D7	GND
D	D0	D3	D5	D6	SBCL	AVDD28

Parameter	Symbol	Nominal	Min.	Max.
Package Body Dimension X	A	2980	2955	3005
Package Body Dimension Y	B	2354	2329	2379
Package Height	C	720	660	780
Ball Height	C1	130	100	160
Package Body Thickness	C2	590	555	625
Glass Thickness	C3	445	425	465
Ball Diameter	D	230	200	260
Total Ball Count	N	24	—	—
Ball Count X axis	N1	6	—	—
Ball Count Y axis	N2	4	—	—
Pin pitch X axis	J1	490		
Pin pitch Y axis	J2	490		
Edge to Pin Center Distance along X axis	S1	265	235	295
Edge to Ball Center Distance along Y axis	S2	442	412	472

Table 2 Package Dimensions

Pin#	Pin Name	I/O	Description
A1	D0M	O	MIPI data output -
A2	CKP	O	MIPI clock output +
A3	VCC	VP	MIPI Power 2.8V
A4	ECLK	I	Input Clock
A5	PCLK	O	Pixel Output Clock
A6	SBDA	I/O	Slave Tri-state, I2C data bus
B1	D0P	O	MIPI data output +
B2	CKM	O	MIPI clock output -
B3	VSS	VG	MIPI ground
B4	PWDN	I	Power down,"0"normal
B5	HSYNC	O	Horizontal Sync signal
B6	VSYNC	O	Vertical Sync signal
C1	D1	O	Pixel Array Output bit1
C2	D2	O	Pixel Array Output bit2
C3	D4	O	Pixel Array Output bit4
C4	DVDD	DP	Digital IO power 2.8V
C5	D7	O	Pixel Array Output bit7
C6	GND	DG	Digital Ground
D1	D0	O	Pixel Array Output bit0
D2	D3	O	Pixel Array Output bit3
D3	D5	O	Pixel Array Output bit5

D4	D6	O	Pixel Array Output bit6
D5	SBCL	I	Slave I^2C clock bus
D6	AVDD28	AP	Analog Power 2.8V

Table 3 Pin Description

Chief Ray Angle

Pixel Array Information

Unit Pixel size: 2.2um

		Value
Active pixel array	X-axis	644
	Y-axis	484
RIC(mm)	X-axis edge	0.708
	Y-axis edge	0.678
	Diagonal edge	0.980

Figure 11 Pixel Array Information

RIC: Radius from the image center

CRA Information

Field(%)	RIC(mm)	CRA(deg)
0	0	0.00
5	0.049	1.54
10	0.098	3.08
15	0.147	4.63
20	0.196	6.17
25	0.245	7.72
30	0.294	9.26
35	0.343	10.80
40	0.392	12.32
45	0.441	13.83
50	0.49	15.31
55	0.539	16.76
60	0.588	18.17
65	0.637	19.53
70	0.686	20.83
75	0.735	22.08
80	0.784	23.25
85	0.833	24.35
90	0.882	25.36
95	0.931	26.25
100	0.98	27.02

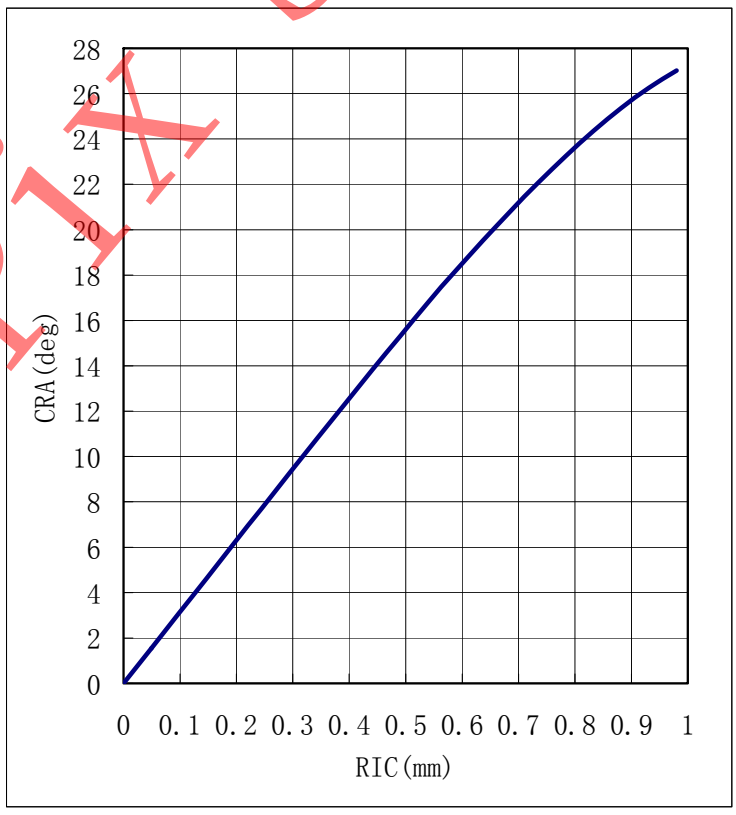


Figure 12 CRA Information

Revision History

Version	Date	Description
Commercial 1.0	2013.03.14	1. The first version for customers.
Commercial 1.1	2013.05.23	1. revise the description of the second page, which in correspondence with flyer
Commercial 1.2	2013.07.05	1. add power up/off sequence 2. add CRA information 3. revise the pixel array description, the first left bottom pixel is blue 4. edit package information, ref 2013.07.04 v3.0