



Diagonal 6.46 mm (Type 1/2.8) CMOS Solid-state Image Sensor with Square Pixel for Color Cameras

Preliminary

IMX290LQR-C

STARVIS

Description

The IMX290LQR-C is a diagonal 6.46 mm (Type 1/2.8) CMOS active pixel type solid-state image sensor with a square pixel array and 2.13 M effective pixels. This chip operates with analog 2.9 V, digital 1.2 V, and interface 1.8 V triple power supply, and has low power consumption. High sensitivity, low dark current and no smear are achieved through the adoption of R, G and B primary color mosaic filters. This chip features an electronic shutter with variable charge-integration time.

(Applications: Surveillance cameras, FA cameras, Industrial cameras)

Features

- ◆ CMOS active pixel type dots
- ◆ Built-in timing adjustment circuit, H/V driver and serial communication circuit
- ◆ Input frequency: 74.25 MHz / 37.125 MHz
- ◆ Number of recommended recording pixels: 1920 (H) × 1080 (V) approx. 2.07M pixel
- ◆ Readout mode
 - All-pixel scan mode
 - 720p-HD readout mode
 - Window cropping mode
 - Vertical / Horizontal direction-normal / inverted readout mode
- ◆ Readout rate
 - Maximum frame rate in Full HD 1080p mode: 120 frame / s
- ◆ Wide dynamic range (WDR) function
 - Multiple exposure WDR
 - Digital overlap WDR
- ◆ Variable-speed shutter function (resolution 1H units)
- ◆ 10-bit / 12-bit A/D converter
- ◆ Conversion gain switching (HCG Mode / LCG Mode)
- ◆ CDS / PGA function
 - 0 dB to 30 dB: Analog Gain 30 dB (step pitch 0.3 dB)
 - 30.3 dB to 72 dB: Analog Gain 30 dB + Digital Gain 0.3 to 42 dB (step pitch 0.3 dB)
- ◆ Supports I/O switching
 - CMOS logic parallel SDR output
 - Low voltage LVDS (150 m Vp-p) serial (2 ch / 4 ch / 8ch switching) DDR output
 - CSI-2 serial data output (2 Lane / 4 Lane, RAW10 / RAW12 output)
- ◆ Recommended exit pupil distance: -30 mm to -∞

Exmor R

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Device Structure

- ◆ CMOS image sensor
- ◆ Image size
Type 1/2.8
- ◆ Total number of pixels
1945 (H) × 1109 (V) approx. 2.16 M pixels
- ◆ Number of effective pixels
1945 (H) × 1097 (V) approx. 2.13 M pixels
- ◆ Number of active pixels
1937 (H) × 1097 (V) approx. 2.12 M pixels
- ◆ Number of recommended recording pixels
1920 (H) × 1080 (V) approx. 2.07 M pixels
- ◆ Unit cell size
2.9 µm (H) × 2.9 µm (V)
- ◆ Optical black
Horizontal (H) direction: Front 0 pixels, rear 0 pixels
Vertical (V) direction: Front 10 pixels, rear 0 pixels
- ◆ Dummy
Horizontal (H) direction: Front 0 pixels, rear 3 pixels
Vertical (V) direction: Front 0 pixels, rear 0 pixels
- ◆ Substrate material
Silicon

Absolute Maximum Ratings

Item	Symbol	Min.	Max.	Unit	Remarks
Supply voltage (analog 2.9 V)	AV _{DD}	-0.3	3.3	V	
Supply voltage (interface 1.8 V)	OV _{DD}	-0.3	3.3	V	
Supply voltage (digital 1.2 V)	DV _{DD}	-0.3	2.0	V	
Input voltage	VI	-0.3	OV _{DD} + 0.3	V	Not exceed 3.3 V
Output voltage	VO	-0.3	OV _{DD} + 0.3	V	Not exceed 3.3 V

Application Conditions

Item	Symbol	Min.	Typ.	Max.	Unit
Supply voltage (analog 2.9 V)	AV _{DD}	2.80	2.90	3.00	V
Supply voltage (Interface 1.8 V)	OV _{DD}	1.70	1.80	1.90	V
Supply voltage (digital 1.2 V)	DV _{DD}	1.10	1.20	1.30	V
Performance guarantee temperature	Tspec	-10	—	60	°C
Operating guarantee temperature	Topr	-30	—	85	°C
Storage guarantee temperature	Tstg	-40	—	85	°C

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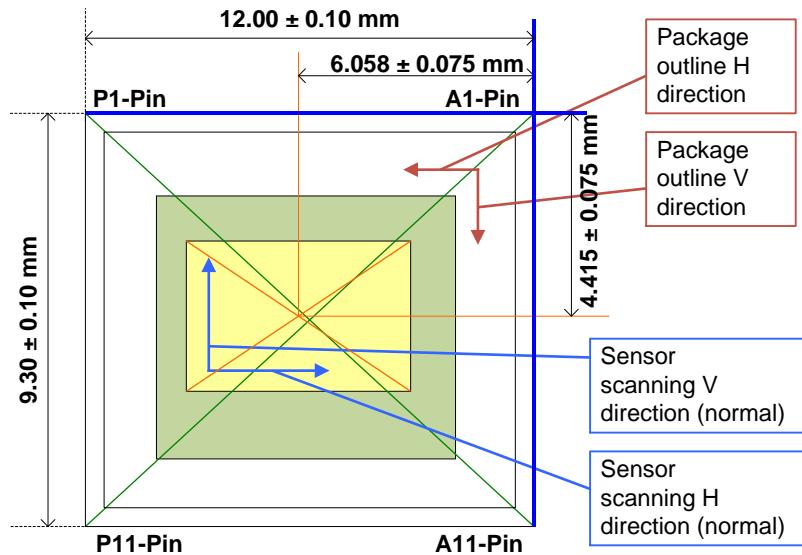
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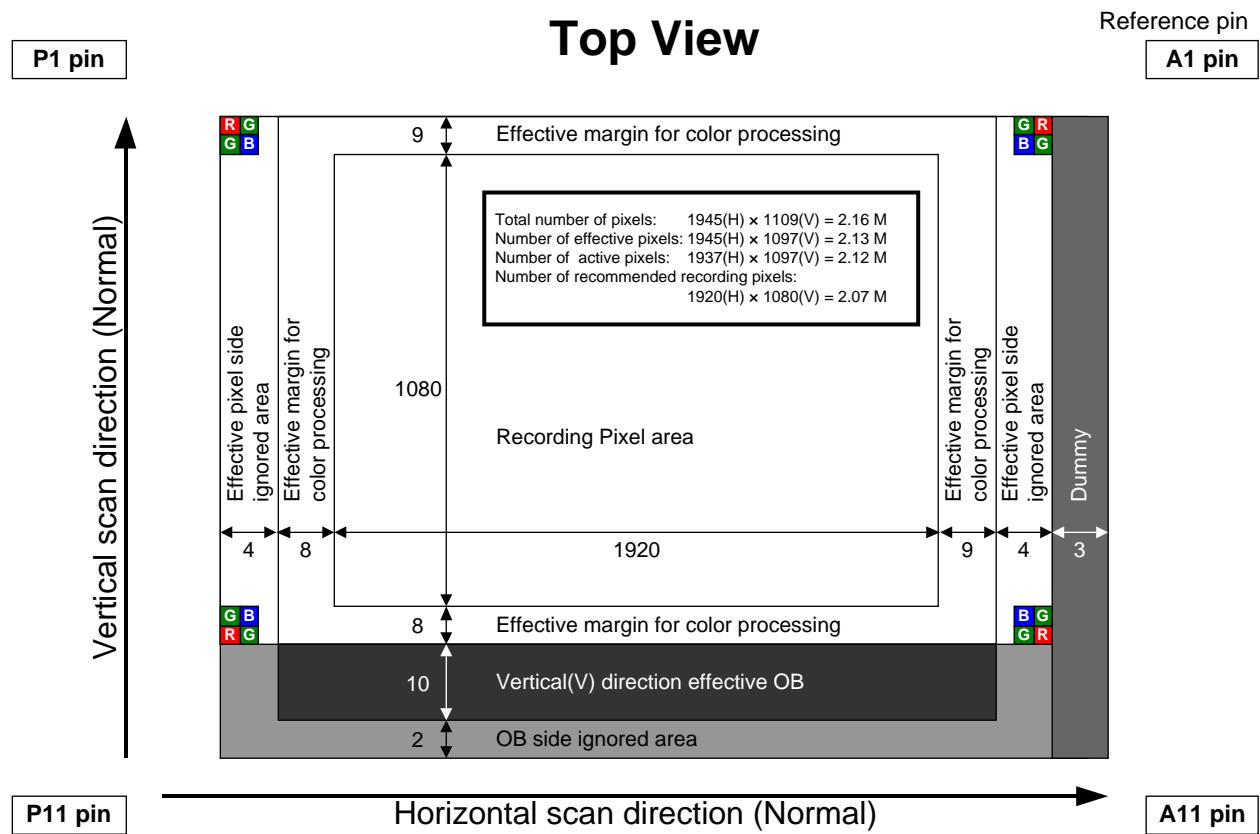
Optical Center**Top View**

- Package center
- Optical center
- Package reference (H, V)



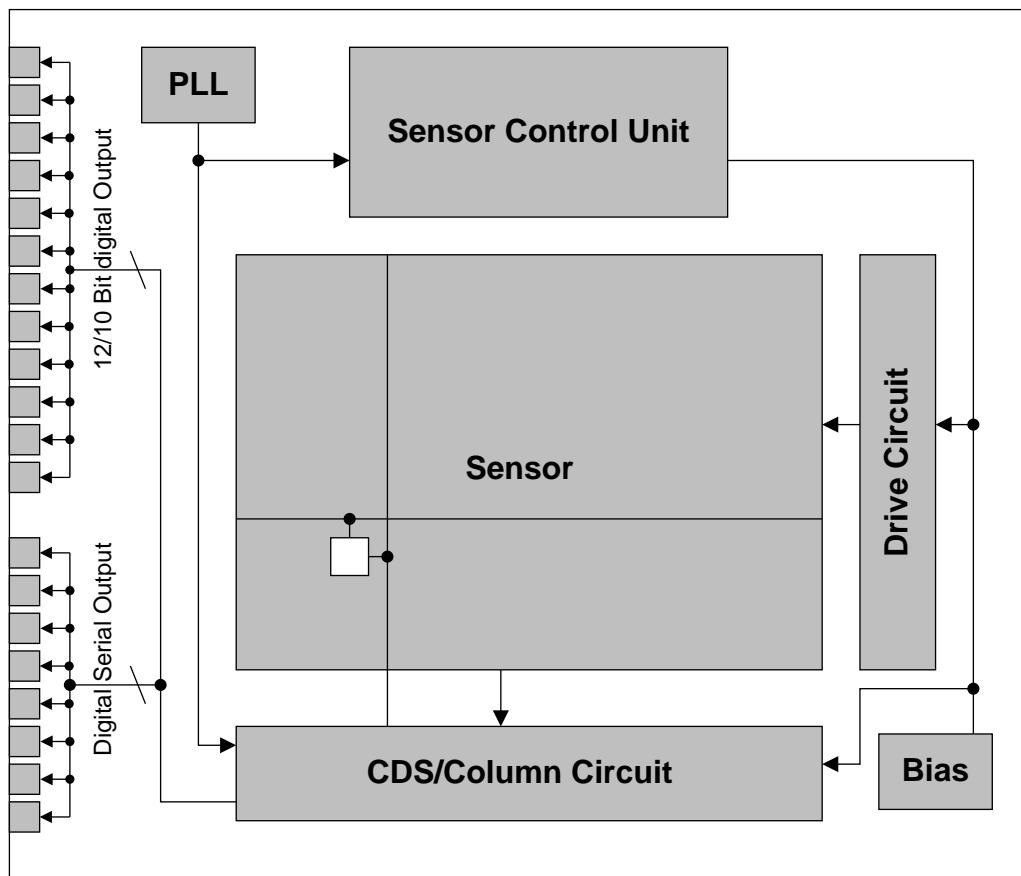
Optical Center

Pixel Arrangement

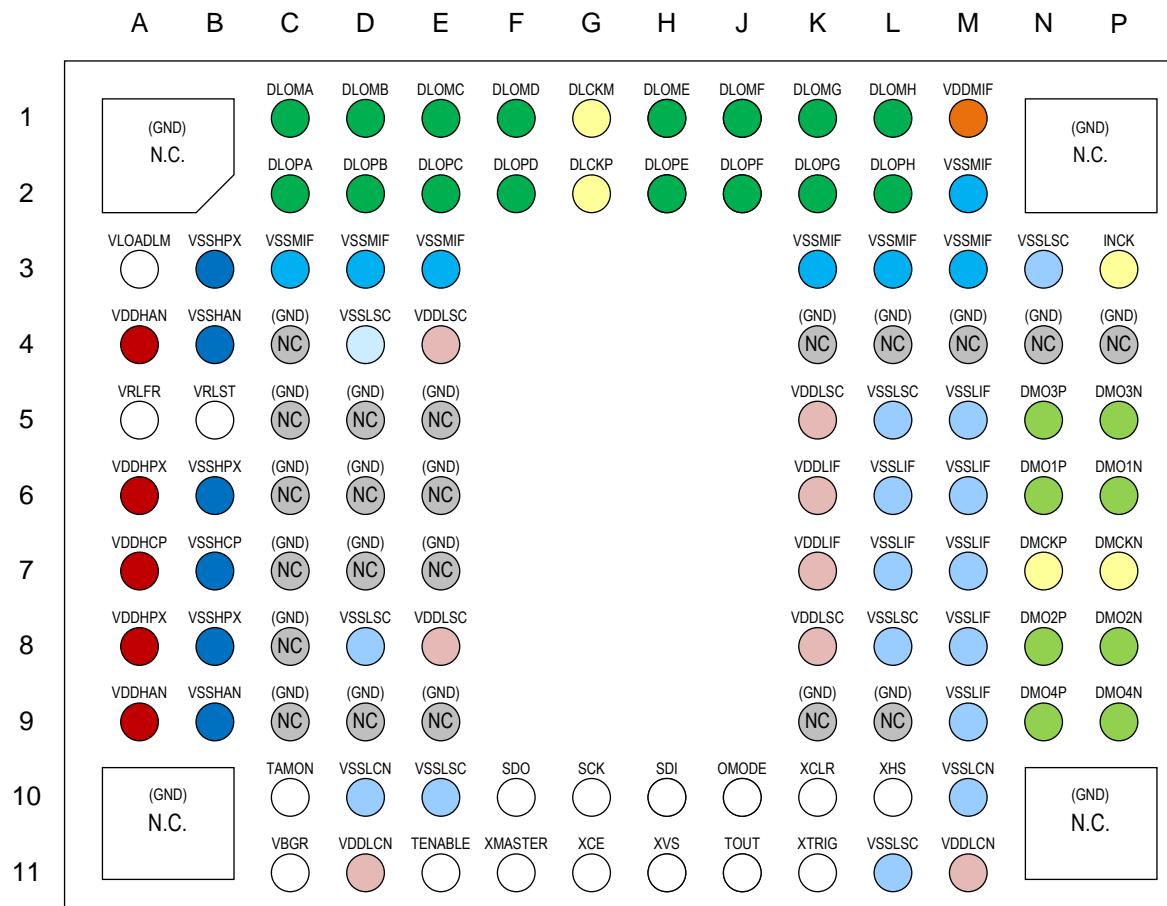


* Reference pin number is consecutive numbering of package pin array.
See the Pin Configuration for the number of each pin.

Pixel Arrangement (Top View)

Block Diagram and Pin Configuration

Block Diagram



- Analog Power Supply (2.9V)
- Digital Power Supply (1.8V)
- Digital Power Supply (1.2V)
- Clock
- Analog GND
- Digital GND
- Digital GND
- Data output (CMOS/LVDS)
- Data output (CSI-2)

*The N.C. pin that is shown with (GND) can be connected to GND.

Pin Configuration (Bottom View)

Pin Description

No.	Pin No	I/O	Analog /Digital	Symbol	Description	Remarks
1	A1	—	—	N.C.	—	GND connectable
2	A3	O	A	VLOADLM	Reference pin	
3	A4	Power	A	VDDHAN	2.9 V power supply	
4	A5	O	A	VRLFR	Reference pin	
5	A6	Power	A	VDDHPX	2.9 V power supply	
6	A7	Power	A	VDDHCP	2.9 V power supply	
7	A8	Power	A	VDDHPX	2.9 V power supply	
8	A9	Power	A	VDDHAN	2.9 V power supply	
9	A11	—	—	N.C.	—	GND connectable
10	B3	GND	A	VSSHPX	2.9 V GND	
11	B4	GND	A	VSSHAN	2.9 V GND	
12	B5	O	A	VRLST	Reference pin	
13	B6	GND	A	VSSHPX	2.9 V GND	
14	B7	GND	A	VSSHCP	2.9 V GND	
15	B8	GND	A	VSSHPX	2.9 V GND	
16	B9	GND	A	VSSHAN	2.9 V GND	
17	C1	O	D	DLOMA	CMOS output / LVDS output	data
18	C2	O	D	DLOPA	CMOS output / LVDS output	data
19	C3	GND	D	VSSMIF	1.8 V GND	
20	C4	—	—	N.C.	—	GND connectable
21	C5	—	—	N.C.	—	GND connectable
22	C6	—	—	N.C.	—	GND connectable
23	C7	—	—	N.C.	—	GND connectable
24	C8	—	—	N.C.	—	GND connectable
25	C9	—	—	N.C.	—	GND connectable
26	C10	O	A	TAMON	TEST output pin	OPEN
27	C11	O	A	VBGR	Reference pin	
28	D1	O	D	DLOMB	CMOS output / LVDS output	data
29	D2	O	D	DLOPB	CMOS output / LVDS output	data
30	D3	GND	D	VSSMIF	1.8 V GND	
31	D4	GND	D	VSSLSC	1.2 V GND	
32	D5	—	—	N.C.	—	GND connectable
33	D6	—	—	N.C.	—	GND connectable
34	D7	—	—	N.C.	—	GND connectable
35	D8	GND	D	VSSLSC	1.2 V GND	
36	D9	—	—	N.C.	—	GND connectable
37	D10	GND	D	VSSLCN	1.2 V GND	
38	D11	Power	D	VDDLGN	1.2 V power supply	

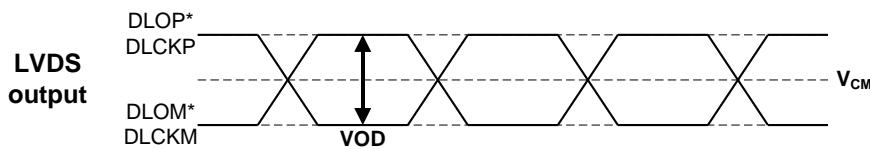
No.	Pin No	I/O	Analog /Digital	Symbol	Description	Remarks
39	E1	O	D	DLOMC	CMOS output / LVDS output	data
40	E2	O	D	DLOPC	CMOS output / LVDS output	data
41	E3	GND	D	VSSMIF	1.8 V GND	
42	E4	Power	D	VDDLSC	1.2 V power supply	
43	E5	—	—	N.C.	—	GND connectable
44	E6	—	—	N.C.	—	GND connectable
45	E7	—	—	N.C.	—	GND connectable
46	E8	Power	D	VDDLSC	1.2 V power supply	
47	E9	—	—	N.C.	—	GND connectable
48	E10	GND	D	VSSLSC	1.2 V GND	
49	E11	I	D	TENABLE	TEST Enable	OPEN
50	F1	O	D	DLOMD	CMOS output / LVDS output	data
51	F2	O	D	DLOPD	CMOS output / LVDS output	data
52	F10	O	D	SDO	Communication output	4-wire: SDO pin I ² C: Open
53	F11	I	D	XMASTER	Master / Slave selection	High: Slave mode / Low: Master mode
54	G1	O	D	DLCKM	CMOS output / LVDS output	clock
55	G2	O	D	DLCKP	CMOS output / LVDS output	clock
56	G10	I	D	SCK	Communication clock	4-wire: SCK pin I ² C: SCL pin
57	G11	I	D	XCE	Communication enable	4-wire: XCE pin I ² C: Fixed to High
58	H1	O	D	DLOME	CMOS output / LVDS output	data
59	H2	O	D	DLOPE	CMOS output / LVDS output	data
60	H10	I/O	D	SDI	Communication input	4-wire: SDI pin I ² C: SDA pin
61	H11	I/O	D	XVS	Vertical sync signal	
62	J1	O	D	DLOMF	CMOS output / LVDS output	data
63	J2	O	D	DLOPF	CMOS output / LVDS output	data
64	J10	I	D	OMODE	Serial output interface selection	High: LVDS / Low: CSI-2
65	J11	O	D	TOUT	TEST output pin	OPEN
66	K1	O	D	DLOMG	CMOS output / LVDS output	data
67	K2	O	D	DLOPG	CMOS output / LVDS output	data
68	K3	GND	D	VSSMIF	1.8 V GND	
69	K4	—	—	N.C.	—	GND connectable
70	K5	Power	D	VDDLSC	1.2 V power supply	
71	K6	Power	D	VDDLIF	1.2 V power supply	
72	K7	Power	D	VDDLIF	1.2 V power supply	
73	K8	Power	D	VDDLSC	1.2 V power supply	
74	K9	—	—	N.C.	—	GND connectable
75	K10	I	D	XCLR	System clear	High: Normal / Low: Clear
76	K11	I	D	XTRIG	Trigger mode input	OPEN
77	L1	O	D	DLOMH	CMOS output / LVDS output	data
78	L2	O	D	DLOPH	CMOS output / LVDS output	data

No.	Pin No	I/O	Analog /Digital	Symbol	Description	Remarks
79	L3	GND	D	VSSMIF	1.8 V GND	
80	L4	—	—	N.C.	—	GND connectable
81	L5	GND	D	VSSLSC	1.2 V GND	
82	L6	GND	D	VSSLIF	1.2 V GND	
83	L7	GND	D	VSSLIF	1.2 V GND	
84	L8	GND	D	VSSLSC	1.2 V GND	
85	L9	—	—	N.C.	—	GND connectable
86	L10	I/O	D	XHS	Horizontal sync signal	
87	L11	GND	D	VSSLSC	1.2 V GND	
88	M1	Power	D	VDDMIF	1.8 V power supply	
89	M2	GND	D	VSSMIF	1.8 V GND	
90	M3	GND	D	VSSMIF	1.8 V GND	
91	M4	—	—	N.C.	—	GND connectable
92	M5	GND	D	VSSLIF	1.2 V GND	
93	M6	GND	D	VSSLIF	1.2 V GND	
94	M7	GND	D	VSSLIF	1.2 V GND	
95	M8	GND	D	VSSLIF	1.2 V GND	
96	M9	GND	D	VSSLIF	1.2 V GND	
97	M10	GND	D	VSSLCN	1.2 V GND	
98	M11	Power	D	VDDLNC	1.2 V power supply	
99	N3	GND	D	VSSLSC	1.2 V GND	
100	N4	—	—	N.C.	—	GND connectable
101	N5	O	D	DMO3P	CSI-2 output	data
102	N6	O	D	DMO1P	CSI-2 output	data
103	N7	O	D	DMCKP	CSI-2 output	clock
104	N8	O	D	DMO2P	CSI-2 output	data
105	N9	O	D	DMO4P	CSI-2 output	data
106	P1	—	—	N.C.	—	GND connectable
107	P3	I	D	INCK	Master clock input	
108	P4	—	—	N.C.	—	GND connectable
109	P5	O	D	DMO3N	CSI-2 output	data
110	P6	O	D	DMO1N	CSI-2 output	data
111	P7	O	D	DMCKN	CSI-2 output	clock
112	P8	O	D	DMO2N	CSI-2 output	data
113	P9	O	D	DMO4N	CSI-2 output	data
114	P11	—	—	N.C.	—	GND connectable

Electrical Characteristics

DC Characteristics

Item		Pins	Symbol	Condition	Min.	Typ.	Max.	Unit
Supply voltage	analog	VDDHx	AV _{DD}		2.80	2.90	3.00	V
	Interface	VDDMx	OV _{DD}		1.70	1.80	1.90	V
	digital	VDDLx	DV _{DD}		1.10	1.20	1.30	V
Digital input voltage		XHS XVS XCLR INCK XMASTER OMODE SCK SDI XCE XTRIG	VIH	XVS / XHS Slave Mode	0.8OV _{DD}	—	—	V
			VIL		—	—	0.2OV _{DD}	V
Digital output voltage		DLOP [A:F] DLOM [A:F] DLCKP DLCKM	VOH	IOH = -2 mA	OV _{DD} -0.4	—	—	V
			VOL	IOL = 2 mA	—	—	0.4	V
			VCM	Low voltage LVDS	—	OV _{DD} /2	—	V
			VOD	Low voltage LVDS (Termination resistance: 100 Ω)	100	150	220	mV
		XHS XVS SDO TOUT	VOH	XVS / XHS Master Mode	OV _{DD} -0.4	—	—	V
			VOL		—	—	0.4	V



Current Consumption

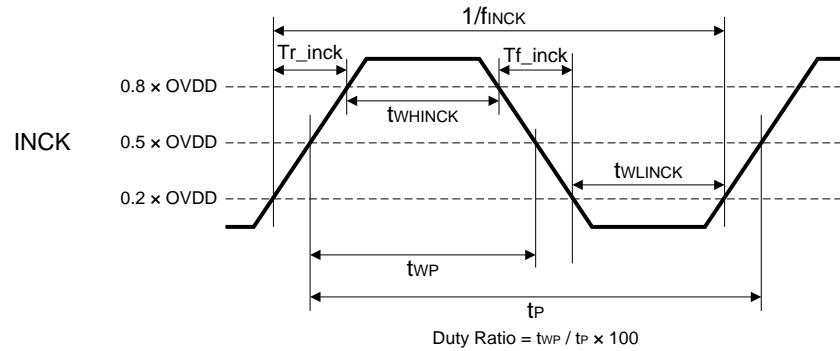
Item	pin	Symbol	Typ.		Max.		Unit
			Standard luminous intensity	Saturated luminous intensity	Standard luminous intensity	Saturated luminous intensity	
Operating current Low voltage LVDS serial 8 ch 12 bit 60 frame / s Full HD 1080p mode	VDDH	IAV _{DD}	54	53	111	108	mA
	VDDM	IOV _{DD}	16	15	29	27	mA
	VDDL	IDV _{DD}	77	95	123	214	mA
Operating current MIPI CSI-2 / 4 Lane 12 bit, 60 frame/s Full HD 1080p mode	VDDH	IAV _{DD}	55	54	111	108	mA
	VDDM	IOV _{DD}	1	1	2	2	mA
	VDDL	IDV _{DD}	94	111	143	252	mA
Operating current CMOS parallel SDR 12 bit, 30 frame/s Full HD 1080p	VDDH	IAV _{DD}	55	54	111	110	mA
	VDDM	IOV _{DD}	17	17	28	28	mA
	VDDL	IDV _{DD}	49	59	90	159	mA
Standby current	VDDH	IAV _{DD_STB}	—		0.1		mA
	VDDM	IOV _{DD_STB}	—		0.1		mA
	VDDL	IDV _{DD_STB}	—		14.0		mA

Operating current:
 (Typ.) Supply voltage 2.90 V / 1.8 V / 1.2 V, T_j = 25 °C
 (Max.) Supply voltage 3.00 V / 1.9 V / 1.3 V, T_j = 60 °C, worst state of internal circuit operating current consumption,
 Standby:
 (Max.) Supply voltage 3.00 V / 1.9 V / 1.3 V, T_j = 60 °C, INCK: 0 V, light-obstructed state.

Standard luminous intensity: luminous intensity at 1/3 of the sensor saturated
 Saturated luminous intensity: luminous intensity when the sensor is saturated.

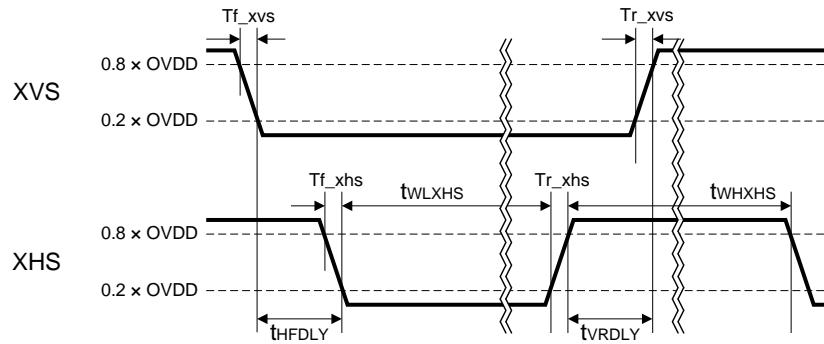
AC Characteristics

Master Clock Waveform (INCK)



Item	Symbol	Min.	Typ.	Max.	Unit	Remarks
INCK clock frequency	f _{INCK}	f _{INCK} × 0.96	f _{INCK}	f _{INCK} × 1.02	MHz	f _{INCK} = 37.125 MHz, 74.25 MHz
INCK Low level pulse width	t _{WLINCK}	4	—	—	ns	f _{INCK} = 37.125 MHz, 74.25 MHz
INCK High level pulse width	t _{WHINCK}	4	—	—	ns	f _{INCK} = 37.125 MHz, 74.25 MHz
INCK clock duty	—	45.0	50.0	55.0	%	Define with 0.5 × OV _{DD}
INCK Rise time	Tr _{_inck}	—	—	5	ns	20 % to 80 %
INCK Fall time	Tf _{_inck}	—	—	5	ns	80 % to 20 %

*The INCK fluctuation affects the frame rate.

XVS / XHS Input Characteristics In Slave Mode (XMASTER pin = High)

Item	Symbol	Min.	Typ.	Max.	Unit	Remarks
XHS Low level pulse width	t_{WLXHS}	$4 / f_{INCK}$	—	—	ns	
XHS High level pulse width	t_{WHXHS}	$4 / f_{INCK}$	—	—	ns	
XVS - XHS fall width	t_{HFDLY}	$1 / f_{INCK}$	—	—	ns	
XHS - XVS rise width	t_{VRDLY}	$1 / f_{INCK}$	—	—	ns	
XVS Rise time	Tr_{xvs}	—	—	5	ns	20 % to 80 %
XVS Fall time	Tf_{xvs}	—	—	5	ns	80 % to 20 %
XHS Rise time	Tr_{xhs}	—	—	5	ns	20 % to 80 %
XHS Fall time	Tf_{xhs}	—	—	5	ns	80 % to 20 %

XVS / XHS Input Characteristics In Master Mode (DMODE pin = Low, CMOS Output)

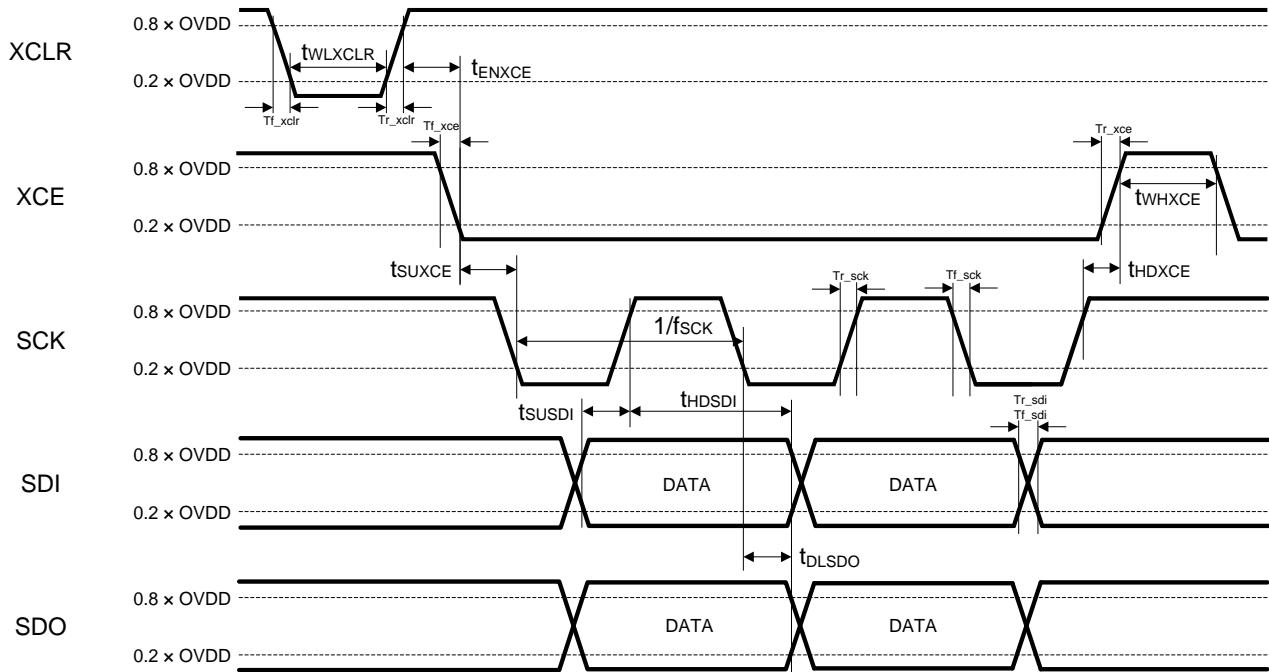
* XVS and XHS cannot be used for the sync signal to pixels.

Be sure to detect sync code to detect the start of effective pixels in 1 line.

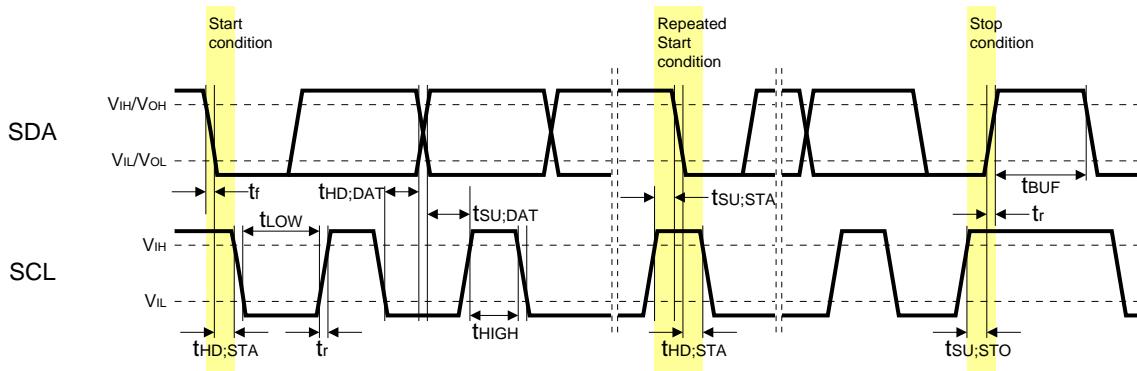
For the output waveforms in master mode, see the item of "Slave Mode and Master Mode"

Serial Communication

4-wire



Item	Symbol	Min.	Typ.	Max.	Unit	Remarks
SCK clock frequency	f_{SCK}	—	—	13.5	MHz	
XCLR Low level pulse width	t_{WLXCLR}	$4 / f_{INCK}$	—	—	ns	
XCE effective margin	t_{ENXCE}	20	—	—	μs	
XCE input set-up time	t_{SUXCE}	20	—	—	ns	
XCE input hold time	t_{HDXCE}	20	—	—	ns	
XCE High level pulse width	t_{WHXCE}	20	—	—	ns	
SDI input set-up time	t_{SUSDI}	10	—	—	ns	
SDI input hold time	t_{HDSDI}	10	—	—	ns	
SDO output delay time	t_{DLSDO}	0	—	25	ns	Output load capacitance: 20 pF
XCLR Rise time	Tr_{xclr}	—	—	5	ns	20 % to 80 %
XCLR Fall time	Tf_{xclr}	—	—	5	ns	80 % to 20 %
XCE Rise time	Tr_{xce}	—	—	5	ns	20 % to 80 %
XCE Fall time	Tf_{xce}	—	—	5	ns	80 % to 20 %
SCK Rise time	Tr_{sck}	—	—	5	ns	20 % to 80 %
SCK Fall time	Tf_{sck}	—	—	5	ns	80 % to 20 %
SDI Rise time	Tr_{sdi}	—	—	5	ns	20 % to 80 %
SDI Fall time	Tf_{sdi}	—	—	5	ns	80 % to 20 %

I^2C  I^2C Specification

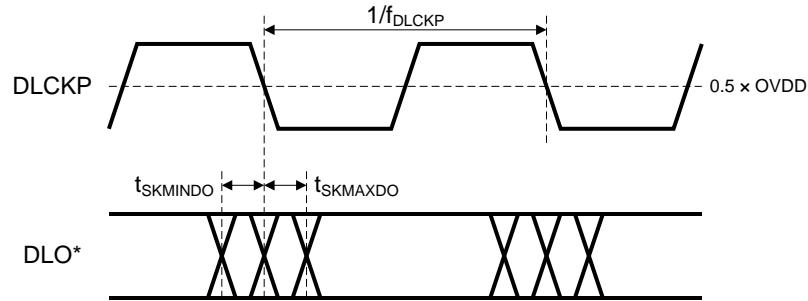
Item	Symbol	Min.	Typ.	Max.	Unit	条件
Low level input voltage	V _{IL}	-0.3	—	0.3 × OV _{DD}	V	
High level input voltage	V _{IH}	0.7 × OV _{DD}	—	1.9	V	
Low level input voltage	V _{OL}	0	—	0.2 × OV _{DD}	V	OV _{DD} < 2 V, Sink 3 mA
High level input voltage	V _{OH}	0.8 × OV _{DD}	—	—	V	
Output fall time	t _{of}	—	—	250	ns	Load 10 pF – 400 pF, 0.7 × OV _{DD} – 0.3 × OV _{DD}
Input current	I _{II}	-10	—	10	μA	0.1 × OV _{DD} – 0.9 × OV _{DD}
Capacitance for SCK (SCL) /SDI (SDA)	C _i	—	—	10	pF	

 I^2C AC Characteristics

Item	Symbol	Min.	Typ.	Max.	Unit
SCL clock frequency	f _{SCL}	0	—	400	kHz
Hold time (Start Condition)	t _{HD;STA}	0.6	—	—	μs
Low period of the SCL clock	t _{LOW}	1.3	—	—	μs
High period of the SCL clock	t _{HIGH}	0.6	—	—	μs
Set-up time (Repeated Start Condition)	t _{SU;STA}	0.6	—	—	μs
Data hold time	t _{HD;DAT}	0	—	0.9	μs
Data set-up time	t _{SU;DAT}	100	—	—	ns
Rise time of both SDA and SCL signals	t _r	—	—	300	ns
Fall time of both SDA and SCL signals	t _f	—	—	300	ns
Set-up time (Stop Condition)	t _{SU;STO}	0.6	—	—	μs
Bus free time between a STOP and START Condition	t _{BUF}	1.3	—	—	μs

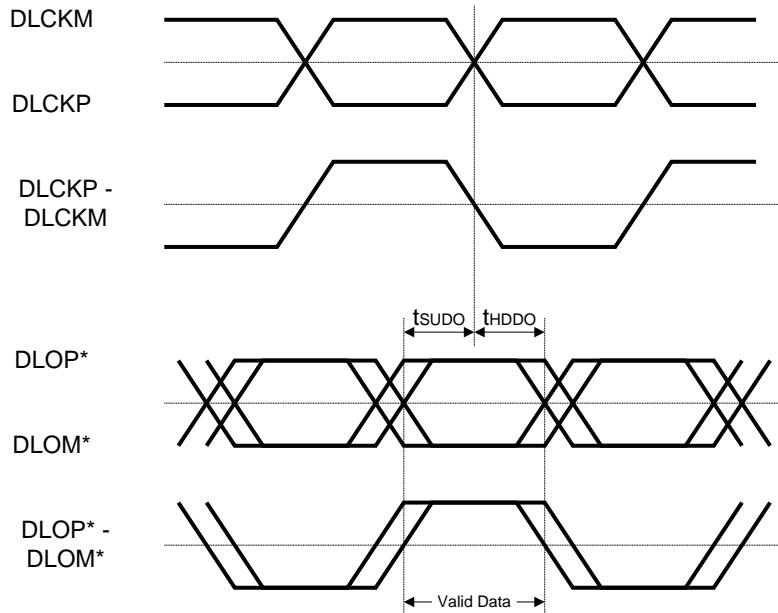
DLCKP / DLCKM, DLOP / DLOM

CMOS Outputs



Item	Symbol	Min.	Typ.	Max.	Unit	Remarks
DLCKP frequency	f_{DLCKP}	—	—	74.25	MHz	
DLCKP clock duty	—	40	50	60	%	
DLCKP - DLO skew Max.	$t_{SKMAXDO}$	—	—	2	ns	Output load capacitance: 20 pF
DLCKP - DLO skew Min.	$t_{SKMINDO}$	—	—	2	ns	Output load capacitance: 20 pF

Low Voltage LVDS DDR Output



(Output load capacitance: 8 pF)

Item	Symbol	Min.	Typ.	Max.	Unit	Remarks
DLCKP/DLCKM clock duty	—	40	50	60	%	DLCK = 297 MHz (Max.)
DLO set-up time	t _{SUDO}	400	—	—	ps	Data Rate 297 MHz DDR
DLO hold time	t _{HDDO}	400	—	—	ps	Data Rate 297 MHz DDR

I/O Equivalent Circuit Diagram

□: External pin

Symbol	Equivalent circuit	Symbol	Equivalent circuit
OMODE TENABLE		XVS XHS	
XMASTER XCE		SDO TOUT	
XCLR INCK		XTRIG	
SDI SCK		VRLFR VRLST	
VLOADLM VBGR TAMON		DLOxP DLOxN DLCKP DLCKN	
DMOPx DMOMx DMCKP DMCKM			

Spectral Sensitivity Characteristics

(Excludes lens characteristics and light source characteristics.)

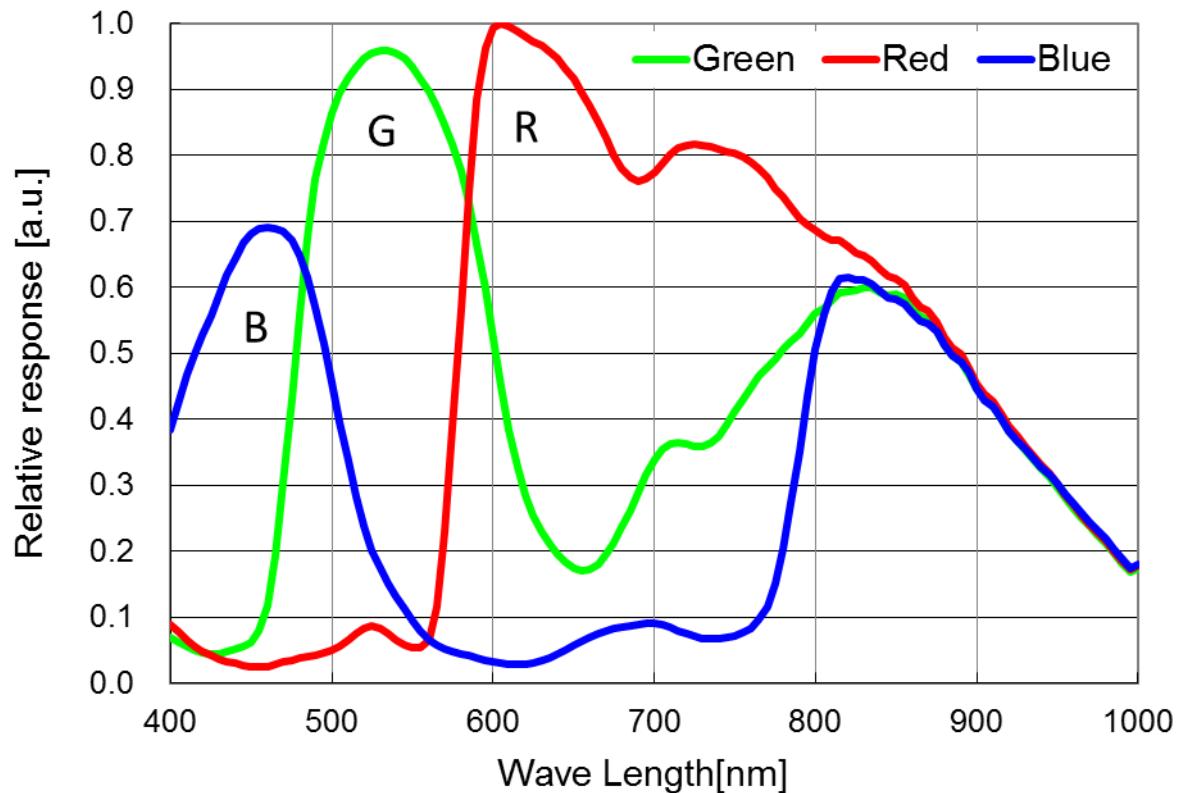


Image Sensor Characteristics

(AV_{DD} = 2.9 V, OV_{DD} = 1.8 V, DV_{DD} = 1.2 V, T_j = 60 °C, All-pixel scan mode, 12 bit 30 frame/s, Gain: 0 dB)

Item	Symbol	Min.	Typ.	Max.	Unit	Measurement method	Remarks
G sensitivity	S	4663 (1105)	5486 (1300)	—	Digit (mV)	1	1/30 s storage 12 bit converted value HCG mode
		2332 (553)	2743 (650)	—	Digit (mV)		1/30 s storage 12 bit converted value LCG mode
Sensitivity ratio	R / G	RG	0.45	—	0.60	—	—
	B / G	BG	0.32	—	0.47	—	
Saturation signal	Vsat	3857 (914)	—	—	Digit (mV)	3	12 bit converted value LCG mode
Video signal shading	SH	—	—	25	%	4	—
Vertical line	VL	—	—	90	μV	5	12 bit converted value LCG mode
Dark signal	Vdt	—	—	0.63 (0.15)	Digit (mV)	6	1/30 s storage 12 bit converted value LCG mode
Dark signal shading	ΔVdt	—	—	0.63 (0.15)	Digit (mV)	7	1/30 s storage 12 bit converted value LCG mode
Conversion efficiency ratio	Rcg	1.8	2	2.2	—	—	HCG mode / LCG mode

Note)

- Converted value into mV using 1Digit = 0.2370 mV for 12-bit output and 1Digit = 0.9479 mV for 10-bit output.
- The video signal shading is the measured value in the wafer status (including color filter) and does not include characteristics of the seal glass.
- The characteristics above apply to effective pixel area that is shown below.

Zone Definition

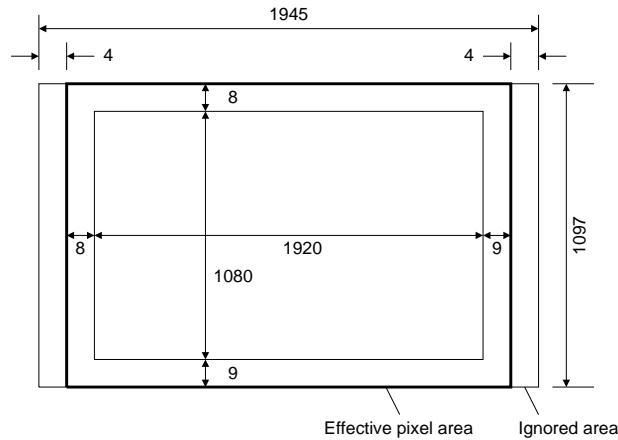


Image Sensor Characteristics Measurement Method

Measurement Conditions

1. In the following measurements, the device drive conditions are at the typical values of the bias conditions and clock voltage conditions.
2. In the following measurements, spot pixels are excluded and, unless otherwise specified, the optical black (OB) level is used as the reference for the signal output, which is taken as the value of the Gr / Gb channel signal output or the R / B channel signal output of the measurement system.

Color Coding of Physical Pixel Array

The primary color filters of this image sensor are arranged in the layout shown in the figure below. Gr and Gb represent the G signal on the same line as the R and B signals, respectively. The Gb signal and B signal lines and the R signal and Gr signal lines are output successively.

Gb	B	Gb	B
R	Gr	R	Gr
Gb	B	Gb	B
R	Gr	R	Gr

Color Coding Diagram

Definition of standard imaging conditions

◆ Standard imaging condition I:

Use a pattern box (luminance: 706 cd/m², color temperature of 3200 K halogen source) as a subject. (Pattern for evaluation is not applicable.) Use a testing standard lens with CM500S (t = 1.0 mm) as an IR cut filter and image at F5.6. The luminous intensity to the sensor receiving surface at this point is defined as the standard sensitivity testing luminous intensity.

◆ Standard imaging condition II:

Image a light source (color temperature of 3200 K) with a uniformity of brightness within 2 % at all angles. Use a testing standard lens with CM500S (t = 1.0 mm) as an IR cut filter. The luminous intensity is adjusted to the value indicated in each testing item by the lens diaphragm.

◆ Standard imaging condition III:

Image a light source (color temperature of 3200 K) with a uniformity of brightness within 2 % at all angles. Use a testing standard lens (exit pupil distance - 30 mm) with CM500S (t = 1.0 mm) as an IR cut filter. The luminous intensity is adjusted to the value indicated in each testing item by the lens diaphragm.

Measurement Method

1. Sensitivity

Set the measurement condition to the standard imaging condition I. After setting the electronic shutter mode with a shutter speed of 1/100 s, measure the Gr and Gb signal outputs (VGr, VGb) at the center of the screen, and substitute the values into the following formula.

$$Sg = (VGr + VGb) / 2 \times 100/30 [mV]$$

2. Sensitivity ratio

Set the measurement condition to the standard imaging condition II. After adjusting the average value of the Gr and Gb signal outputs to 650 mV, measure the R signal output (VR [mV]), the Gr and Gb signal outputs (VGr, VGb [mV]) and the B signal output (VB [mV]) at the center of the screen in frame readout mode, and substitute the values into the following formulas.

$$VG = (VGr + VGb) / 2$$

$$RG = VR / VG$$

$$BG = VB / VG$$

3. Saturation signal I

Set the measurement condition to the standard imaging condition II. After adjusting the luminous intensity to 20 times the intensity with the average value of the Gr and Gb signal outputs, 650 mV, measure the average values of the Gr, Gb, R and B signal outputs.

4. Video signal shading

Set the measurement condition to the standard imaging condition III. With the lens diaphragm at F2.8, adjust the luminous intensity so that the average value of the Gr and Gb signal outputs is 650 mV. Then measure the maximum value (Gmax [mV]) and the minimum value (Gmin [mV]) of the Gr and Gb signal outputs, and substitute the values into the following formula.

$$SH = (Gmax - Gmin) / 650 \times 100 [\%]$$

5. Vertical Line

With the device junction temperature of 60 °C and the device in the light-obstructed state, calculates each average output of Gr, Gb, R and B on respective columns. Calculates maximum value of difference with adjacent column on the same color (VL [μ V]).

6. Dark signal

With the device junction temperature of 60 °C and the device in the light-obstructed state, divide the output difference between 1/30 s integration and 1/300 s integration by 0.9, and calculate the signal output converted to 1/30 s integration. Measure the average value of this output (Vdt [mV]).

7. Dark signal shading

After the measurement item 5, measure the maximum value (Vdmax [mV]) and the minimum value (Vdmin [mV]) of the dark signal output, and substitute the values into the following formula.

$$\Delta Vdt = Vdmax - Vdmin [mV]$$

Setting Registers Using Serial Communication

This sensor can write and read the setting values of the various registers shown in the Register Map by 4-wire serial communication and I²C communication. See the Register Map for the addresses and setting values to be set. Because the two communication systems are judged at the first communication, once they are judged, the communication cannot be switched until sensor reset. The pin for 4-wire serial communication and I²C communication is shared, so the external pin XCE must be fixed to power supply side when using I²C communication.

Description of Setting Registers (4-wire)

The serial data input order is LSB-first transfer. The table below shows the various data types and descriptions.

Serial Data Transfer Order

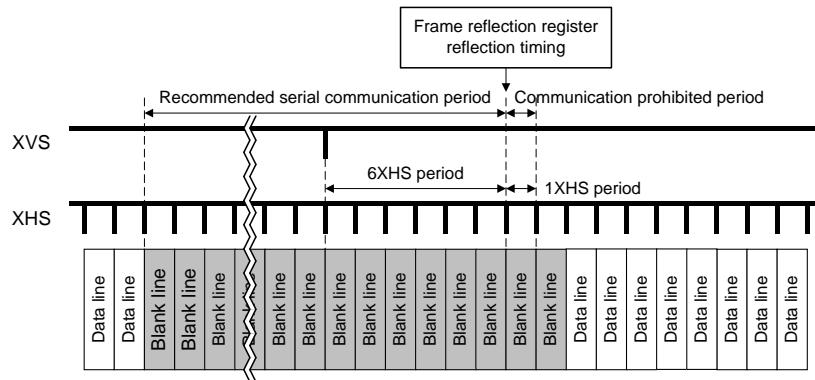
Chip ID	Start address	Data	Data	Data	...
(8 bit)	(8 bit)	(8 bit)	(8 bit)	(8 bit)	(8 bit)

Type and Description

Type	Description
ChipID	02h: Write to the Chip ID = 02h register 03h: Write to the Chip ID = 03h register 04h: Write to the Chip ID = 04h register 05h: Write to the Chip ID = 05h register 06h: Write to the Chip ID = 06h register 82h: Read from the Chip ID = 02h register 83h: Read from the Chip ID = 03h register 84h: Read from the Chip ID = 04h register 85h: Read from the Chip ID = 05h register 86h: Read from the Chip ID = 06h register
Address	Designate the address according to the Register Map. When using a communication method that designates continuous addresses, the address is automatically incremented from the previously transmitted address.
Data	Input the setting values according to the Register Map.

Register Communication Timing (4-wire)

Perform serial communication in sensor standby mode or within in the 6XHS period after the falling edge of XVS from the blanking line output start time after valid line of one frame is finished. For the registers marked "V" in the item of Reflection timing, when the communication is performed in the communication period shown in the figure below they are reflected by frame reflection timing. For the registers noted "Immediately" in the item of Reflection timing, the settings are reflected when the communication is performed. (For the immediate reflection registers other than STANDBY, REGHOLD, XMSTA, SW_RESET, XVSOUTSEL [1:0] and XHSOUTSEL [1:0], set them in sensor standby state.)



Register Write and Read (4-wire)

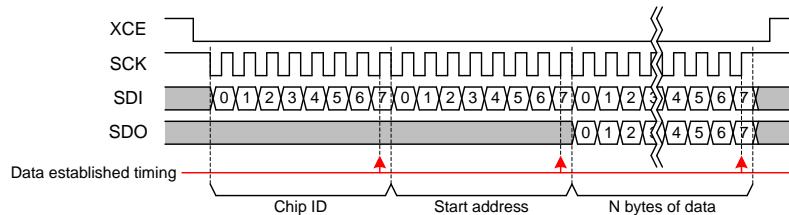
Follow the communication procedure below when writing registers.

1. Set XCE Low to enable the chip's communication function. Serial data input is executed using SCK and SDI.
2. Transmit data in sync with SCK 1 bit at a time from the LSB using SDI. Transfer SDI in sync with the falling edge of SCK. (The data is loaded at the rising edge of SCK.)
3. Input Chip ID (CID = 02h or 03h or 04h or 05h or 06h) to the first byte. If the Chip ID differs, subsequent data is ignored.
4. Input the start address to the second byte. The address is automatically incremented.
5. Input the data to the third and subsequent bytes. The data in the third byte is written to the register address designated by the second byte, and the register address is automatically incremented thereafter when writing the data for the fourth and subsequent bytes. Normal register data is loaded to the inside of the sensor and established in 8-bit units.
6. The register values starting from the register address designated by the second byte are output from the SDO pin. The register values before the write operation are output. The actual register values are the input data.
7. Set XCE High to end communication.

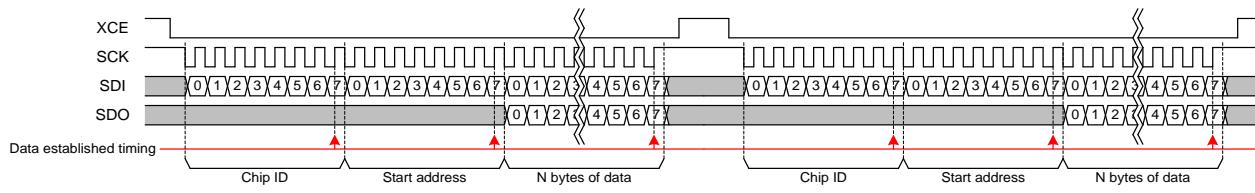
Follow the communication procedure below when reading registers.

1. Set XCE Low to enable the chip's communication function. Serial data input is executed using SCK and SDI.
2. Transmit data in sync with SCK 1 bit at a time from the LSB using SDI. Transfer SDI in sync with the falling edge of SCK. (The data is loaded at the rising edge of SCK.)
3. Input Chip ID (CID = 82h or 83h or 84h or 85h or 86h) to the first byte. If the Chip ID differs, subsequent data is ignored.
4. Input the start address to the second byte. The address is automatically incremented.
5. Input data to the third and subsequent bytes. Input dummy data in order to read the registers. The dummy data is not written to the registers. To read continuous data, input the necessary number of bytes of dummy data.
6. The register values starting from the register address designated by the second byte are output from the SDO pin. The input data is not written, so the actual register values are output.
7. Set XCE High to end communication.

Note) When writing data to multiple registers with discontinuous addresses, access to undesired registers can be avoided by repeating the above procedure multiple times.



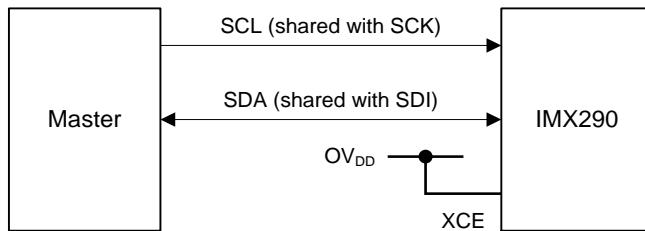
Serial Communication (Continuous Address)



Serial Communication (Discontinuous Address)

Description of Setting Registers (I^2C)

The serial data input order is MSB-first transfer. The table below shows the various data types and descriptions.



Pin connection of serial communication

SLAVE Address

MSB								LSB
0	0	1	1	0	1	0	R / W	

* R/W is data direction bit

R / W

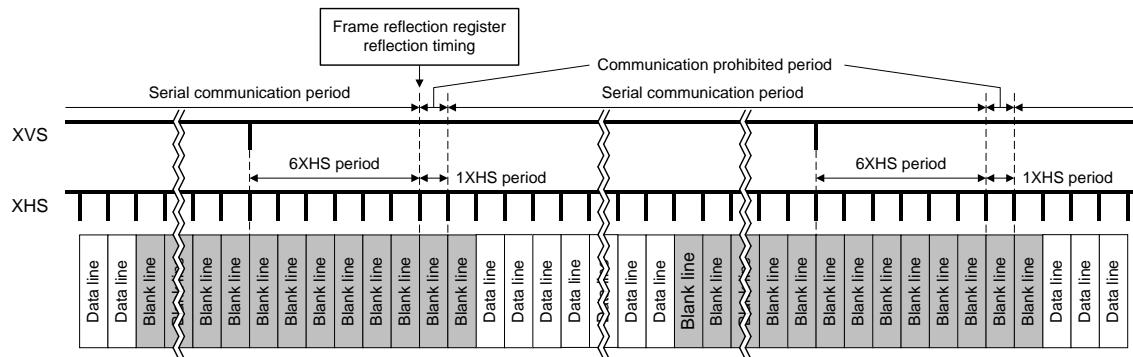
R / W bit	Data direction
0	Write (Master → Sensor)
1	Read (Sensor → Master)

I^2C pin description

Symbol	Pin No.	Remarks
SCL (Common to SCK)	G10	Serial clock input
SDA (Common to SDI)	H10	Serial data communication

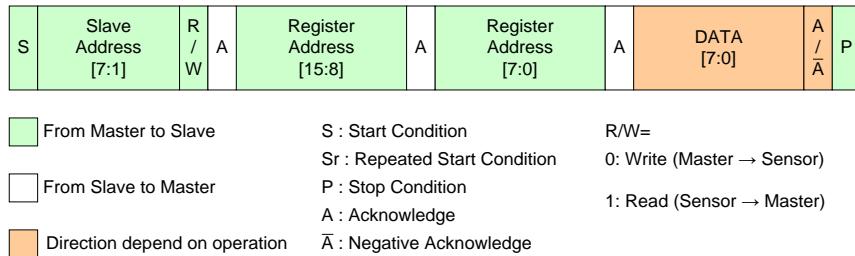
Register Communication Timing (I^2C)

In I^2C communication system, communication can be performed excluding during the period when communication is prohibited from the falling edge of XVS to 6H after (1H period). For the registers marked "V" in the item of Reflection timing, when the communication is performed in the communication period shown in the figure below they are reflected by frame reflection timing. For the registers noted "Immediately" in the item of Reflection timing, the settings are reflected when the communication is performed. (For the immediate reflection registers other than STANDBY, REGHOLD, XMSTA, SW_RESET, XVSOUTSEL [1:0] and XHSOUTSEL [1:0], set them in sensor standby state.) Using REG_HOLD function is recommended for register setting using I^2C communication. For REG_HOLD function, see "Register Transmission Setting" in "Description of Functions".



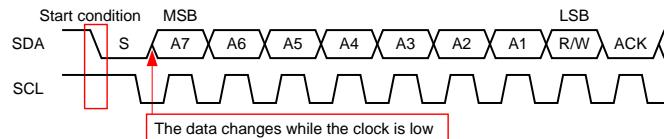
Communication Protocol

I²C serial communication supports a 16-bit register address and 8-bit data message type.

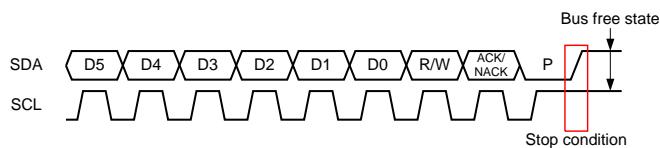


Communication Protocol

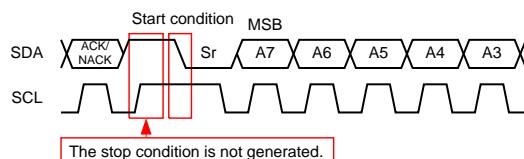
Data is transferred serially, MSB first in 8-bit units. After each data byte is transferred, A (Acknowledge) / Ā (Negative Acknowledge) is transferred. Data (SDA) is transferred at the clock (SCL) cycle. SDA can change only while SCL is Low, so the SDA value must be held while SCL is High. The Start condition is defined by SDA changing from High to Low while SCL is High. When the Stop condition is not generated in the previous communication phase and Start condition for the next communication is generated, that Start condition is recognized as a Repeated Start condition.



Start Condition

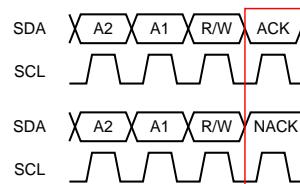


Stop Condition



Repeated Start Condition

After transfer of each data byte, the Master or the sensor transmits an Acknowledge / Negative Acknowledge and release (does not drive) SDA. When Negative Acknowledge is generated, the Master must immediately generate the Stop Condition and end the communication.



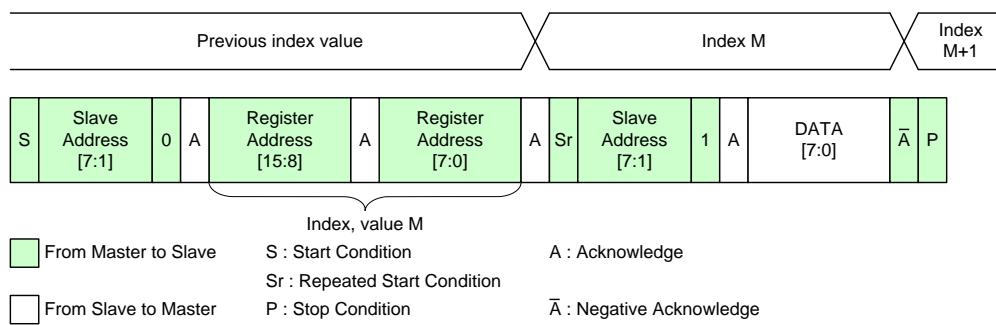
Acknowledge and Negative Acknowledge

Register Write and Read (I^2C)

This sensor corresponds to four read modes and the two write modes.

Single Read from Random Location

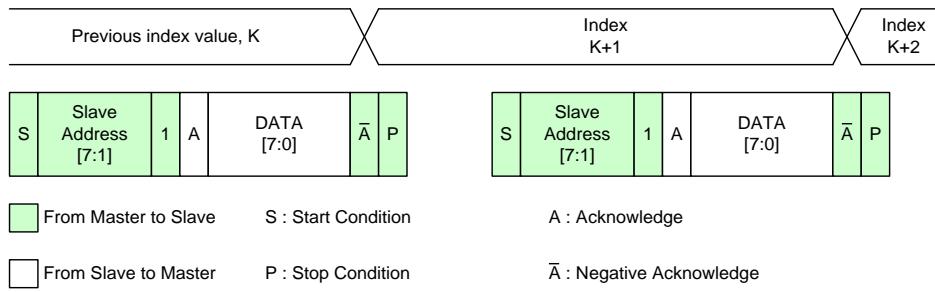
The sensor has an index function that indicates which address it is focusing on. In reading the data at an optional single address, the Master must set the index value to the address to be read. For this purpose it performs dummy write operation up to the register address. The upper level of the figure below shows the sensor internal index value, and the lower level of the figure shows the SDA I/O data flow. The Master sets the sensor index value to M by designating the sensor slave address with a write request, then designating the address (M). Then, the Master generates the start condition. The Start Condition is generated without generating the Stop Condition, so it becomes the Repeated Start Condition. Next, when the Master sends the slave address with a read request, the sensor outputs an Acknowledge immediately followed by the index address data on SDA. After the Master receives the data, it generates a Negative Acknowledge and the Stop Condition to end the communication



Single Read from Random Location

Single Read from Current Location

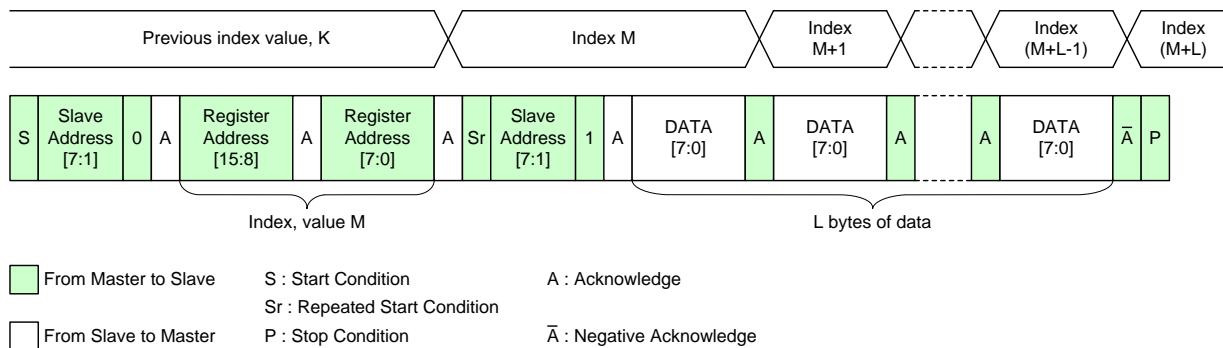
After the slave address is transmitted by a write request, that address is designated by the next communication and the index holds that value. In addition, when data read/write is performed, the index is incremented by the subsequent Acknowledge/Negative Acknowledge timing. When the index value is known to indicate the address to be read, sending the slave address with a read request allows the data to be read immediately after Acknowledge. After receiving the data, the Master generates a Negative Acknowledge and the Stop Condition to end the communication, but the index value is incremented, so the data at the next address can be read by sending the slave address with a read request.



Single Read from Current Location

Sequential Read Starting from Random Location

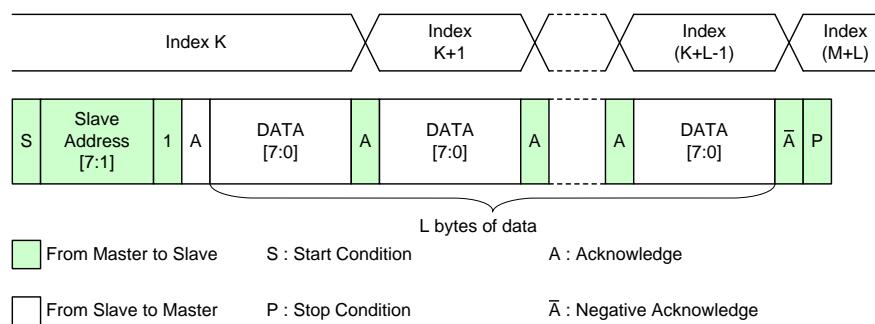
In reading data sequentially, which is starting from an optional address, the Master must set the index value to the start of the addresses to be read. For this purpose, dummy write operation includes the register address setting. The Master sets the sensor index value to M by designating the sensor slave address with a read request, then designating the address (M). Then, the Master generates the Repeated Start Condition. Next, when the Master sends the slave address with a read request, the sensor outputs an Acknowledge followed immediately by the index address data on SDA. When the Master outputs an Acknowledge after it receives the data, the index value inside the sensor is incremented and the data at the next address is output on SDA. This allows the Master to read data sequentially. After reading the necessary data, the Master generates a Negative Acknowledge and the Stop Condition to end the communication.



Sequential Read Starting from Random Location

Sequential Read Starting from Current Location

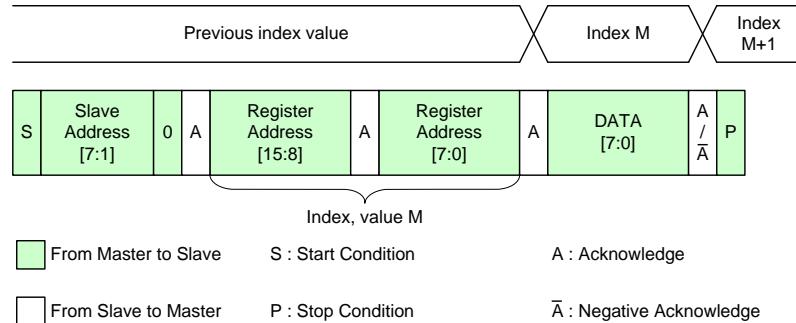
When the index value is known to indicate the address to be read, sending the slave address with a read request allows the data to be read immediately after the Acknowledge. When the Master outputs an Acknowledge after it receives the data, the index value inside the sensor is incremented and the data at the next address is output on SDA. This allows the Master to read data sequentially. After reading the necessary data, the Master generates a Negative Acknowledge and the Stop Condition to end the communication.



Sequential Read Starting from Current Location

Single Write to Random Location

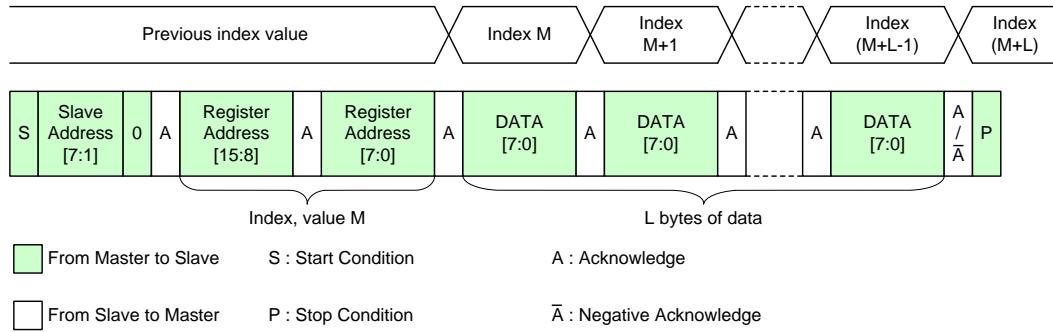
The Master sets the sensor index value to M by designating the sensor slave address with a write request, and designating the address (M). After that the Master can write the value in the designated register by transmitting the data to be written. After writing the necessary data, the Master generates the Stop Condition to end the communication.



Single Write to Random Location

Sequential Write Starting from Random Location

The Master can write a value to register address M by designating the sensor slave address with a write request, designating the address (M), and then transmitting the data to be written. After the sensor receives the write data, it outputs an Acknowledge and at the same time increments the register address, so the Master can write to the next address simply by continuing to transmit data. After the Master writes the necessary number of bytes, it generates the Stop Condition to end the communication.



Sequential Write Starting from Random Location

Register Map

This sensor has a total of 1280 bytes (256×5) of registers, composed of registers with addresses 00h to FFh that correspond to Chip ID = 02h (write mode) / 82h (read mode), Chip ID = 03h (write mode) / 83h (read mode), Chip ID = 04h (write mode) / 84h (read mode), Chip ID = 05h (write mode) / 85h (read mode), and Chip ID = 06h (write mode) / 86h (read mode). Use the initial values for empty address. Some registers must be change from the initial values, so the sensor control side should be capable of setting 1280 bytes.

The values must be changed from the default value, so initial setting after reset is required after power-on. There are two different register reflection timing. Values are reflected immediately after writing to register noted as "Immediately", or at the frame reflection register reflection timing described in the item of "Register Communication Timing" in the section of "Setting Registers with Serial Communication" for registers noted as "V" in the Reflection timing column of the Register Map. For the immediate reflection registers other than belows, set them in sensor standby state.

STANDBY
REGHOLD
XMSTA
SW_RESET
XVSOUTSEL [1:0]
XHSOUTSEL [1:0]

Do not perform communication to addresses not listed in the Register Map. Doing so may result in operation errors. However, other registers that requires communication to address not listed above may be added, so addresses up to FFh should be supported for CID = 02h, 03h, 04h, 05h and 06h. (In I²C communication, address; 3000h to 30FFh, 3100h to 31FFh, 3200h to 32FFh, 3300h to 33FFh, 3400h to 34FFh)

For the register that is writing " * " to the setting value in description (Indicated by red letter), change the value from the default value after the reset.

(1) Registers corresponding to Chip ID = 02h in Write mode. (Read: Chip ID = 82h)

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
00h	3000h	0	STANDBY	Standby 0: Operating 1: Standby	1h	01h	Immediately
		1		Fixed to "0h"	0h		—
		2		Fixed to "0h"	0h		—
		3		Fixed to "0h"	0h		—
		4		Fixed to "0h"	0h		—
		5		Fixed to "0h"	0h		—
		6		Fixed to "0h"	0h		—
		7		Fixed to "0h"	0h		—
01h	3001h	0	REGHOLD	Register hold (Function not to update V reflection register) 0: Invalid 1: Valid	0h	00h	Immediately
		1		Fixed to "0h"	0h		—
		2		Fixed to "0h"	0h		—
		3		Fixed to "0h"	0h		—
		4		Fixed to "0h"	0h		—
		5		Fixed to "0h"	0h		—
		6		Fixed to "0h"	0h		—
		7		Fixed to "0h"	0h		—
02h	3002h	0	XMSTA	Setting of master mode operation 0: Master mode operation start 1: Master mode operation stop	1h	01h	Immediately
		1		Fixed to "0h"	0h		—
		2		Fixed to "0h"	0h		—
		3		Fixed to "0h"	0h		—
		4		Fixed to "0h"	0h		—
		5		Fixed to "0h"	0h		—
		6		Fixed to "0h"	0h		—
		7		Fixed to "0h"	0h		—
03h	3003h	0	SW_RESET	Software reset 0: Operating 1: Reset	0h	00h	Immediately
		1		Fixed to "0h"	0h		—
		2		Fixed to "0h"	0h		—
		3		Fixed to "0h"	0h		—
		4		Fixed to "0h"	0h		—
		5		Fixed to "0h"	0h		—
		6		Fixed to "0h"	0h		—
		7		Fixed to "0h"	0h		—
04h	3004h	[7:0]		Fixed to "10h"	10h	10h	—

Address		bit	Register name	Description	Default value after reset		Reflection timing	
4-wire	I ² C				By register	By address		
05h	3005h	0	ADBIT	AD conversion bits setting 0: 10 bit, 1: 12 bit	1h	01h	v	
		1	—	Fixed to "0h"	0h		—	
		2	—	Fixed to "0h"	0h		—	
		3	—	Fixed to "0h"	0h		—	
		4	—	Fixed to "0h"	0h		—	
		5	—	Fixed to "0h"	0h		—	
		6	—	Fixed to "0h"	0h		—	
		7	—	Fixed to "0h"	0h		—	
06h	3006h	[7:0]	—	Fixed to "00h"	00h	00h	v	
07h	3007h	0	VREVERSE	Vertical (V) direction readout inversion control 0: Normal, 1: Inverted	0h	00h	v	
		1	HREVERSE	Horizontal (H) direction readout inversion control 0: Normal, 1: Inverted	0h		v	
		2	—	Fixed to "0h"	0h		—	
		3	—	Fixed to "0h"	0h		—	
		4	WINMODE [2:0]	Window mode setting 0: Full HD1080p 1: HD720p 4: Window cropping from Full HD 1080p Others: Setting prohibited	0h		v	
		5					—	
		6					—	
		7					—	
08h	3008h	[7:0]	—	Fixed to "A0h"	A0h	A0h	—	
09h	3009h	0	FRSEL [1:0]	Frame rate (Data rate) setting For details, see the register setting list in each operation mode.	2h	02h	v	
		1					—	
		2	—	Fixed to "0h"	0h		—	
		3	—	Fixed to "0h"	0h		—	
		4	FDG_SEL	Conversion gain switching 0: LCG Mode 1: HCG Mode	0h		v	
		5	—	Fixed to "0h"	0h		—	
		6	—	Fixed to "0h"	0h		—	
		7	—	Fixed to "0h"	0h		—	

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
0Ah	300Ah	0	BLKLEVEL [8:0]	LSB Black level offset value setting	0F0h	F0h	V
		1					
		2					
		3					
		4					
		5					
		6					
		7					
0Bh	300Bh	0	MSB		00h	00h	—
		1					
		2					
		3					
		4					
		5					
		6					
		7					
0Ch	300Ch	[7:0]	—	Fixed to "00h"	00h	00h	—
0Dh	300Dh	[7:0]	—	Fixed to "00h"	00h	00h	—
0Eh	300Eh	[7:0]	—	Fixed to "01h"	01h	01h	—
0Fh	300Fh	[7:0]	—	Set to "00h" *	01h	01h	—
10h	3010h	[7:0]	—	Set to "21h" *	01h	01h	—
11h	3011h	[7:0]	—	Fixed to "00h"	00h	00h	—
12h	3012h	[7:0]	—	Set to "64h" *	F0h	F0h	—
13h	3013h	[7:0]	—	Set to "00h"	00h	00h	—
14h	3014h	0	GAIN [7:0]	LSB Gain setting (0.0 dB to 72.0 dB / 0.3 dB step)	00h	00h	V
		1					
		2					
		3					
		4					
		5					
		6					
		7					
15h	3015h	[7:0]	—	Fixed to "00h"	00h	00h	—
16h	3016h	[7:0]	—	Set to "09h"	08h	08h	—
17h	3017h	[7:0]	—	Fixed to "00h"	00h	00h	—

Address		bit	Register name	Description	Default value after reset		Reflection timing	
4-wire	I ² C				By register	By address		
18h	3018h	0	VMAX [17:0]	LSB When sensor master mode vertical span setting. (Number of operation lines count from 1) For details, see the item of "Slave Mode and Master Mode" in the section of "Description of Various Functions"	0465h	65h	V	
		1				04h		
		2						
		3						
		4						
		5						
		6						
		7						
19h	3019h	0				00h	—	
		1						
		2						
		3						
		4						
		5						
		6						
		7						
1Ah	301Ah	0	MSB	Fixed to "0h"	0h	00h	—	
		1			0h			
		2			0h			
		3			0h			
		4			0h			
		5			0h			
		6			0h			
		7			0h			
1Bh	301Bh	[7:0]	LSB	Fixed to "00h"	00h	00h	—	
1Ch	301Ch	0			1130h	30h	V	
		1						
		2						
		3						
		4						
		5						
		6						
		7						
1Dh	301Dh	0	HMAX [15:0]	When sensor master mode horizontal span setting. (Number of operation clocks count from 1) For details, see the item of "Slave Mode and Master Mode" in the section of "Description of Various Functions"	11h	11h	—	
		1						
		2						
		3						
		4						
		5						
		6						
		7						
1Eh	301Eh	[7:0]	MSB	Fixed to "B2h"	B2h	B2h	—	
1Fh	301Fh	[7:0]			01h	01h	—	

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
20h	3020h	0	SHS1 [17:0]	LSB	00000h	00h	V
		1					
		2					
		3					
		4					
		5					
		6					
		7					
21h	3021h	0		Storage time adjustment Designated in line units.		00h	V
		1					
		2					
		3					
		4					
		5					
		6					
		7					
22h	3022h	0	MSB		00h	—	—
		1					
		2		Fixed to "0h"			
		3		Fixed to "0h"			
		4		Fixed to "0h"			
		5		Fixed to "0h"			
		6		Fixed to "0h"			
		7		Fixed to "0h"			
23h to 39h	3023h to 3039h	[7:0] to [7:0]	Reserved		—	—	—
3Ah	303Ah	0		LSB		Ch	V
		1		In window cropping mode			
		2		Cropping size designation (Vertical direction effective OB)			
		3		MSB			
		4		Fixed to "0h"			
		5		Fixed to "0h"			
		6		Fixed to "0h"			
		7		Fixed to "0h"			
3Bh	303Bh	[7:0]	WINPV [10:0]	Fixed to "00h"	00h	00h	—
3Ch	303Ch	0		LSB	000h	00h	V
		1					
		2					
		3					
		4					
		5		In window cropping mode			
		6		Designation of upper left coordinate for cropping position (Vertical position)			
		7					
3Dh	303Dh	0	MSB		00h	00h	—
		1					
		2					
		3		Fixed to "0h"			
		4		Fixed to "0h"			
		5		Fixed to "0h"			
		6		Fixed to "0h"			
		7		Fixed to "0h"			

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
3Eh	303Eh	0	WINWV [10:0]	LSB In window cropping mode Cropping size designation (Vertical direction)	449h	49h	V
		1					
		2					
		3					
		4					
		5					
		6					
		7					
3Fh	303Fh	0		MSB	0h	04h	—
		1					
		2					
		3					
		4					
		5					
		6					
		7					
40h	3040h	0	WINPH [10:0]	LSB In window cropping mode Designation of upper left coordinate for cropping position (horizontal position) Set to become the multiple of four	000h	00h	V
		1					
		2					
		3					
		4					
		5					
		6					
		7					
41h	3041h	0		MSB	0h	00h	—
		1					
		2					
		3					
		4					
		5					
		6					
		7					
42h	3042h	0	WINWH [10:0]	LSB In window cropping mode Cropping size designation (horizontal direction) Set to become the multiple of four	79Ch	9Ch	V
		1					
		2					
		3					
		4					
		5					
		6					
		7					
43h	3043h	0		MSB	0h	07h	—
		1					
		2					
		3					
		4					
		5					
		6					
		7					
44h to 45h	3044h to 3045h	[7:0] to [7:0]	—	Reserved	—	—	—

Address		bit	Register name	Description	Default value after reset		Reflection timing	
4-wire	I ² C				By register	By address		
46h	3046h	0	ODBIT	Number of output bit setting 0: 10 bit, 1: 12 bit * In CSI-2 mode (OMODE = Low), Fixed to "1h".	1h	01h	Immediately	
				Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	
				Output interface selection (In CSI-2, don't care. CSI-2 Interface will be selected by ChipID: 06h register.) 0h: Parallel CMOS SDR Dh: LVDS 2 ch Eh: LVDS 4 ch Fh: LVDS 8 ch Others: Setting prohibited	Immediately			
				Fixed to "01h"	01h		—	
				Fixed to "0h"	0h	00h	—	
				Fixed to "0h"	0h		—	
47h	3047h	[7:0]	—	Fixed to "0h"	0h	01h	—	
				Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	
				XVS pulse width setting in master mode. (In slave mode, setting is invalid.) 0: 1H, 1: 2H, 2: 4H, 3: 8H	0h		Immediately	
				Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	
49h	3049h	0	—	Fixed to "0h"	0h	08h	—	
				Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	
				Fixed to "1h"	1h		—	
				XHS pulse width setting in master mode. (In slave mode, setting is invalid.) 0: Min. to 3: Max.	0h		Immediately	
				Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	
4Ah	304Ah	[7:0]	—	Fixed to "00h"	00h	00h	—	
4Bh	304Bh	0	XVSOUTSEL [1:0]	XVS pin setting in master mode 0: Fixed to High 2: VSYNC output Others: Setting prohibited	0h	00h	Immediately	
				Fixed to "0h"			—	
		2	XHSOUTSEL [1:0]	XHS pin setting in master mode 0: Fixed to High 2: HSYNC output Others: Setting prohibited	0h		Immediately	
				Fixed to "0h"			—	
		4	—	Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	
		6	—	Fixed to "0h"	0h		—	
				Fixed to "0h"	0h		—	

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
4Ch to 5Bh	304Ch to 305Bh	[7:0] to [7:0]	—	Reserved	—	—	—
5Ch	305Ch	[7:0]	INCKSEL1	The value is set according to INCK.	2Ch	2Ch	Immediately
5Dh	305Dh	[7:0]	INCKSEL2	The value is set according to INCK.	10h	10h	Immediately
5Eh	305Eh	[7:0]	INCKSEL3	The value is set according to INCK.	2Ch	2Ch	Immediately
5Fh	305Fh	[7:0]	INCKSEL4	The value is set according to INCK.	10h	10h	Immediately
60h to 6Fh	3060h to 306Fh	[7:0] to [7:0]	—	Reserved	—	—	—
70h	3070h	[7:0]	—	Set to "02h" *	01h	01h	—
71h	3071h	[7:0]	—	Set to "11h" *	00h	00h	—
72h to 9Ah	3072h to 309Ah	[7:0] to [7:0]	—	Reserved	—	—	—
9Bh	309Bh	[7:0]	—	Set to "10h" *	00h	00h	—
9Ch to A1h	309Ch to 30A1h	[7:0] to [7:0]	—	Reserved	—	—	—
A2h	30A2h	[7:0]	—	Set to "02h" *	00h	00h	—
A3h to A5h	30A3h to 30A5h	[7:0] to [7:0]	—	Reserved	—	—	—
A6h	30A6h	[7:0]	—	Set to "20h" *	10h	10h	—
A7h	30A7h	[7:0]	—	Fixed to "00h"	00h	00h	—
A8h	30A8h	[7:0]	—	Set to "20h" *	10h	10h	—
A9h	30A9h	[7:0]	—	Fixed to "00h"	00h	00h	—
AAh	30AAh	[7:0]	—	Set to "20h" *	10h	10h	—
ABh	30ABh	[7:0]	—	Fixed to "00h"	00h	00h	—
ACh	30ACh	[7:0]	—	Set to "20h" *	10h	10h	—
ADh to AFh	30ADh to 30AFh	[7:0] to [7:0]	—	Reserved	—	—	—
B0h	30B0h	[7:0]	—	Set to "43h" *	41h	41h	—
B1h to FFh	30B1h to 30FFh	[7:0] to [7:0]	—	Reserved	—	—	—

(2) Registers corresponding to Chip ID = 03h in Write mode. (Read: Chip ID = 83h)

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
00h ~ 18h	3100h ~ 3118h	[7:0] [7:0]	—	Reserved	—	—	—
19h	3119h	[7:0]	—	Set to "9Eh" *	92h	92h	—
1Ah ~ 1Bh	311Ah ~ 311Bh	[7:0] [7:0]	—	Reserved	—	—	—
1Ch	311Ch	[7:0]	—	Set to "1Eh" *	12h	12h	—
1Dh	311Dh	[7:0]	—	Fixed to "00h"	00h	00h	—
1Eh	311Eh	[7:0]	—	Set to "08h" *	05h	05h	—
1Fh ~ 27h	311Fh ~ 3127h	[7:0] [7:0]	—	Reserved	—	—	—
28h	3128h	[7:0]	—	Set to "05h" *	07h	07h	—
29h	3129h	[7:0]	ADBIT1	The value is set according to AD conversion bits 10bit : 1Dh 12bit : 00h	00h	00h	—
2Ah ~ 3Ch	312Ah ~ 313Ch	[7:0] [7:0]	—	Reserved	—	—	—
3Dh	313D	[7:0]	—	Set to "83h" *	80h	80h	—
3Eh to 4Fh	313Eh to 314Fh	[7:0] [7:0]	—	Reserved	—	—	—
50h	3150h	[7:0]	—	Set to "03h" *	02h	02h	—
51h to 5Dh	3151h to 315Dh	[7:0] [7:0]	—	Reserved	—	—	—
5Eh	315Eh	[7:0]	INCKSEL5	The value is set according to INCK. INCK = 74.25 MHz : 1Bh INCK = 37.125 MHz : 1Ah	1Bh	1Bh	Immediately
5Fh to 63h	315Fh to 3163h	[7:0] [7:0]	—	Reserved	—	—	—
64h	3164h	[7:0]	INCKSEL6	The value is set according to INCK. INCK = 74.25 MHz : 1Bh INCK = 37.125 MHz : 1Ah	1Bh	1Bh	Immediately
65h to 7Bh	3165h to 317Bh	[7:0] [7:0]	—	Reserved	—	—	—

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
7Ch	317Ch	[7:0]	ADBIT2	The value is set according to AD conversion bits 10bit : 12h 12bit : 00h	17h	17h	—
7Dh	317Dh	[7:0]	—	Fixed to "00h"	00h	00h	—
7Eh	317Eh	[7:0]	—	Set to "00h" *	17h	17h	—
7Fh ~ EBh	317Fh ~ 31EBh	[7:0]	—	Reserved	—	—	—
ECh	31ECh	[7:0]	ADBIT3	The value is set according to AD conversion bits 10bit : 37h 12bit : 0Eh	0Eh	0Eh	
EDh ~ FFh	31EDh ~ 31FFh	[7:0]	—	Reserved	—	—	—

(3) Registers corresponding to Chip ID = 04h in Write mode. (Read: Chip ID = 84h)

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
00h	3200h	[7:0]	—	Reserved	—	—	—
~	~	~	—				
B7h	32B7h	[7:0]	—				
B8h	32B8h	[7:0]	—	Set to "50h" *	01h	01h	—
B9h	32B9h	[7:0]	—	Set to "10h" *	00h	00h	—
BAh	32BAh	[7:0]	—	Set to "00h" *	05h	05h	—
BBh	32BBh	[7:0]	—	Set to "04h" *	00h	00h	—
BCh	32BCh	[7:0]	—	Reserved	—	—	—
~	~	~	—				
C7h	32C7h	[7:0]	—				
C8h	32C8h	[7:0]	—	Set to "50h" *	01h	01h	—
C9h	32C9h	[7:0]	—	Set to "10h" *	00h	00h	—
CAh	32CAh	[7:0]	—	Set to "00h" *	05h	05h	—
CBh	32CBh	[7:0]	—	Set to "04h" *	00h	00h	—
CCh	32CCh	[7:0]	—	Reserved	—	—	—
~	~	~	—				
FFh	32FFh	[7:0]	—				

(4) Registers corresponding to Chip ID = 05h in Write mode. (Read: Chip ID = 85h)

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
00h	3300h	[7:0]	—	Reserved	—	—	—
~ 2Bh	~ 332Bh	[7:0]	—				
2Ch	332Ch	[7:0]	—	Set to "D3h" *	D1h	D1h	—
2Dh	332Dh	[7:0]	—	Set to "10h" *	F0h	F0h	—
2Eh	332Eh	[7:0]	—	Set to "0Dh" *	0Ch	0Ch	—
2Fh	332Fh	[7:0]	—	Reserved	—	—	—
~ 57h	~ 3357h	[7:0]	—				
58	3358h	[7:0]	—	Set to "06h" *	FFh	FFh	—
59	3359h	[7:0]	—	Set to "E1h" *	F3h	F3h	—
5A	335Ah	[7:0]	—	Set to "11h" *	3Fh	3Fh	—
5Bh	335Bh	[7:0]	—	Reserved	—	—	—
~ 5Fh	~ 335Fh	[7:0]	—				
60h	3360h	[7:0]	—	Set to "1Eh" *	E0h	E0h	—
61h	3361h	[7:0]	—	Set to "61h" *	C0h	C0h	—
62h	3362h	[7:0]	—	Set to "10h" *	0Dh	0Dh	—
63h	3363h	[7:0]	—	Reserved	—	—	—
~ AFh	~ 33AFh	[7:0]	—				
B0h	33B0h	[7:0]	—	Set to "50h" *	03h	03h	—
B1h	33B1h	[7:0]	—	Fixed to "80h" *	80h	80h	—
B2h	33B2h	[7:0]	—	Set to "1Ah"	00h	00h	—
B3h	33B3h	[7:0]	—	Set to "04h" *	00h	00h	—
B4h	33B4h	[7:0]	—	Reserved	—	—	—
~ FFh	~ 33FFh	[7:0]	—				

(5) Registers corresponding to Chip ID = 06h in Write mode. (Read: Chip ID = 86h)
 * These registers are set in CSI-2 interface only.

Address		bit	Register name	Description	Default value after reset		Reflection timing	
4-wire	I ² C				By register	By address		
00h to 04h	3400h to 3404h	[7:0] to [7:0]	—	Reserved	—	—	—	
05h	3405h	0	—	Fixed to "0h"	0h	20h	—	
		1	—	Fixed to "0h"	0h		—	
		2	—	Fixed to "0h"	0h		—	
		3	—	Fixed to "0h"	0h		—	
		4	REPETITION [1:0]	* Refer to "Output signal Interface Control" section.	2h		Immediately	
		5						
		6	—	Fixed to "0h"	0h		—	
		7	—	Fixed to "0h"	0h		—	
06h	3406h	[7:0]	—	Fixed to "00h"	00h	00h	—	
07h	3407h	0	PHYSICAL_LANE_NUM [1:0]	Physically connect the Lane number	3h	03h	Immediately	
		1	—					
		2	—	Fixed to "0h"	0h		—	
		3	—	Fixed to "0h"	0h		—	
		4	—	Fixed to "0h"	0h		—	
		5	—	Fixed to "0h"	0h		—	
		6	—	Fixed to "0h"	0h		—	
		7	—	Fixed to "0h"	0h		—	
08h to 13h	3408h to 3413h	[7:0] to [7:0]	—	Reserved	—	—	—	
14h	3414h	0	OPB_SIZE_V [5:0]	LSB Vertical (V) direction OB width setting. * Refer to each operating setting.	0Ah	0Ah	Immediately	
		1						
		2						
		3						
		4						
		5						
		6		MSB				
		7		Fixed to "0h"	0h		—	
15h to 17h	3415h to 3417h	[7:0] to [7:0]	—	Reserved	—	—	—	
18h	3418h	0	Y_OUT_SIZE [12:0]	LSB Vertical (V) direction effective pixel width setting. * Refer to each operating setting.	0449h	49h	Immediately	
		1						
		2						
		3						
		4						
		5						
		6						
		7						
19h	3419h	0				04h	—	
		1						
		2						
		3						
		4						
		5	—	MSB				
		6	—	Fixed to "0h"	0h		—	
		7	—	Fixed to "0h"	0h		—	

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
1Ah to 2Bh	341Ah to 342Bh	[7:0] to [7:0]	—	Reserved	—	—	—
2Ch	342Ch	[7:0]	THSEXIT[15:0]	Global timing setting	0047h	47h 00h	Immediately
2Dh	342Dh	[7:0]				00h	
2Eh to 2Fh	342Eh to 342Fh	[7:0] to [7:0]	—	Reserved	—	—	—
30h	3430h	[7:0]	TCLKPRE[8:0]	Global timing setting	00Fh	0Fh 00h	Immediately
31h	3431h	0				00h	
32h to 40h	3432h to 3440h	[7:0] to [7:0]	—	Fixed to “00h”	00h	—	—
41h	3441h	[7:0]	CSI_DT_FMT [15:0]	LSB RAW10: 0A0Ah / RAW12: 0C0Ch MSB	0C0Ch	0Ch	Immediately
42h	3442h	[7:0]				0Ch	
43h	3443h	[1:0]	CSI_LANE_MODE [1:0]	Lane number setting 0: Setting prohibited, 1: 2Lane, 3: 4Lane 2: Setting prohibited	3h	03h	Immediately
		[7:2]	—	Fixed to “00h”	00h		
44h	3444h	[7:0]	EXTCK_FREQ [15:0]	LSB Master clock frequency 2520h: INCK = 37.125 MHz 4A40h: INCK = 74.25 MHz MSB	4A40h	40h	Immediately
45h	3445h	[7:0]				4Ah	
46h	3446h	[7:0]	TCLKPOST[8:0]	Global timing setting	047h	47h 00h	Immediately
47h	3447h	0				00h	
48h	3448h	[7:0]	THSZERO[8:0]	Global timing setting	01Fh	1Fh 00h	Immediately
49h	3449h	0				00h	
4Ah	344Ah	[7:0]	THSPREPARE [8:0]	Global timing setting	017h	17h 00h	Immediately
4Bh	344Bh	[7:1]				00h	
4Ch	344Ch	[7:0]	TCLKTRAIL[8:0]	Global timing setting	00Fh	0Fh 00h	Immediately
4Dh	344Dh	0				00h	
4Eh	344Eh	[7:0]	THSTRAIL[8:0]	Global timing setting	017h	17h 00h	Immediately
4Fh	344Fh	0				00h	
50h	3450h	[7:0]	TCLKZERO[8:0]	Global timing setting	047h	47h 00h	Immediately
51h	3451h	0				00h	
52h	3452h	[7:0]	TCLKPREPARE [8:0]	Global timing setting	00Fh	0Fh 00h	Immediately
53h	3453h	[7:1]				00h	

Address		bit	Register name	Description	Default value after reset		Reflection timing
4-wire	I ² C				By register	By address	
54h	3454h	[7:0]	TLPX[8:0] 0	Global timing setting Fixed to "00h"	00Fh	0Fh	Immediately
55h	3455h	[7:1]				00h	
56h to 71h	3456h to 3471h	[7:0] to [7:0]	—	Reserved	—	—	—
72h	3472h	0	X_OUT_SIZE [12:0]	LSB Horizontal (H) direction effective pixel width setting. * Refer to each operating setting.	079Ch	9Ch	Immediately
		1					
		2					
		3					
		4					
		5					
		6					
		7					
73h	3473h	0	MSB	Fixed to "0h"	0h	07h	—
		1					
		2					
		3					
		4					
		5					
		6					
		7					
74h to FFh	3474h to 34FFh	[7:0] to [7:0]	—	Reserved	—	—	—

Readout Drive mode

The table below lists the operating modes available with this sensor. (N/A: Not supported mode)

Window	Mode	INCK [MHz]	AD conversion [bit]	Output bit width [bit]	Frame rate [frame/s]	Data rate					
						Parallel CMOS [Mpixel/s]	Serial LVDS [Mbps/ch]			CSI-2 [Mbps/Lane]	
							2 ch	4 ch	8 ch	2 Lane	4 Lane
Full HD 1080p	All pixel	37.125 74.25	10/12	10/12	30 / 25	74.25	445.5	222.75	111.375	445.5	222.75
			10/12	10/12	60 / 50	N/A	N/A	445.5	222.75	891	445.5
			10	10	120/100	N/A	N/A	N/A	445.5	N/A	891
	Window cropping	37.125 74.25	10/12	10/12	*1	74.25	445.5	222.75	111.375	445.5	222.75
			10/12	10/12	*2	N/A	N/A	445.5	222.75	891	445.5
			10	10	*3	N/A	N/A	N/A	445.5	N/A	891
HD720p	All-pixel	37.125 74.25	10/12	10/12	30	37.125	297	148.5	N/A	297	148.5
			10/12	10/12	60	74.25	594	297	N/A	594	297
			10	10	120	N/A	N/A	594	N/A	N/A	594

*1: FRSEL = 2h

*2: FRSEL = 1h

*3: FRSEL = 0h

Window	Mode	INCK [MHz]	Frame rate [frame/s]	Recording pixels		Total number of pixels			1H period [μs]	
				H [pixels]	V [lines]	H [pixels]		V [lines]		
						CMOS (10 bit/ 12 bit)	LVDS CSI-2 (10 bit)	LVDS CSI-2 (12 bit)		
Full HD 1080p	All-pixel	37.125 74.25	25	1920	1080	2640	3168	2640	1125	35.6
			30			2200	2640	2200		29.6
			50			N/A	3168	2640		17.8
			60			N/A	2640	2200		14.8
			100			N/A	3168	N/A		8.9
			120			N/A	2640	N/A		7.4
	Window cropping	37.125 74.25	*1	*4	*4	2200	2640	2200	*5	29.6
			*2			N/A				14.8
			*3			N/A				7.4
			25			1980	3168	2640		53.3
HD720p	All-pixel	37.125 74.25	30	1280	720	1650	2640	2200	750	44.4
			50			1980	3168	2640		26.7
			60			1650	2640	2200		22.2
			100			N/A	3168	N/A		13.3
			120			N/A	2640	N/A		11.1

*1: FRSEL = 2h

*2: FRSEL = 1h

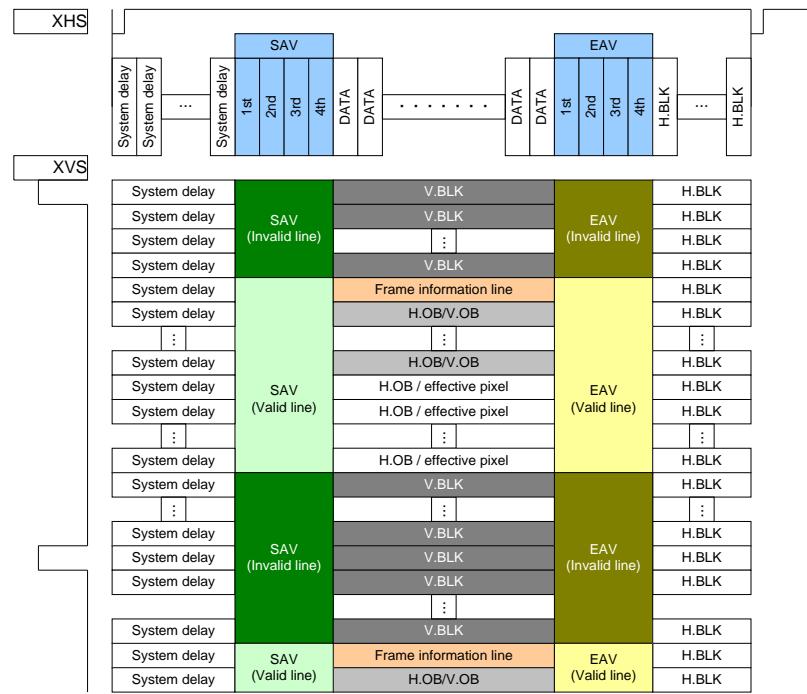
*3: FRFES = 0h

*4: Arbitrary value that was designated to cropping area

*5: Please refer to description of window cropping mode

Sync code (Parallel CMOS output / Serial LVDS output)

The sync code is added immediately before and after "dummy signal + OB signal + effective pixel data" and then output. The sync code is output in order of 1st, 2nd, 3rd and 4th. The fixed value is output for 1st to 3rd.
(BLK: Blanking period)



Sync Code Output Timing

List of Sync Code

Sync code	1st code		2nd code		3rd code		4th code	
	10 bit	12 bit						
SAV (Valid line)	3FFh	FFFh	000h	000h	000h	000h	200h	800h
EAV (Valid line)	3FFh	FFFh	000h	000h	000h	000h	274h	9D0h
SAV (Invalid line)	3FFh	FFFh	000h	000h	000h	000h	2ACh	AB0h
EAV (Invalid line)	3FFh	FFFh	000h	000h	000h	000h	2D8h	B60h

(Note 1) 10 bit is the value output to the DLOP/M [C:G] when the register ODBIT = 0 in parallel output.

(Note 2) 12 bit is the value output to the DLOP/M [B:G] when the register ODBIT = 1 in parallel output.

(Note 3) They are output to each channel seriously in MSB first when low-voltage LVDS serial.

For details, see the item of "Signal output" and "Output pin setting".

Sync Code Output Timing

The sensor output signal passes through the internal circuits and is output with a latency time (system delay) relative to the horizontal sync signal. This system delay value is undefined for each line, so refer to the sync codes output from the sensor and perform synchronization.

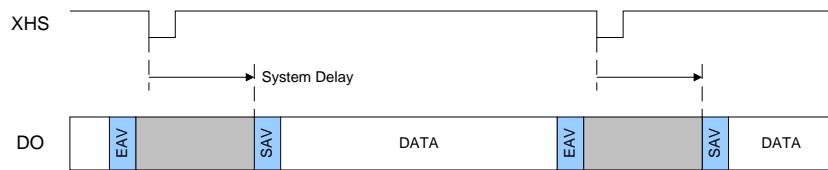


Image Data Output Format (CSI-2 output)

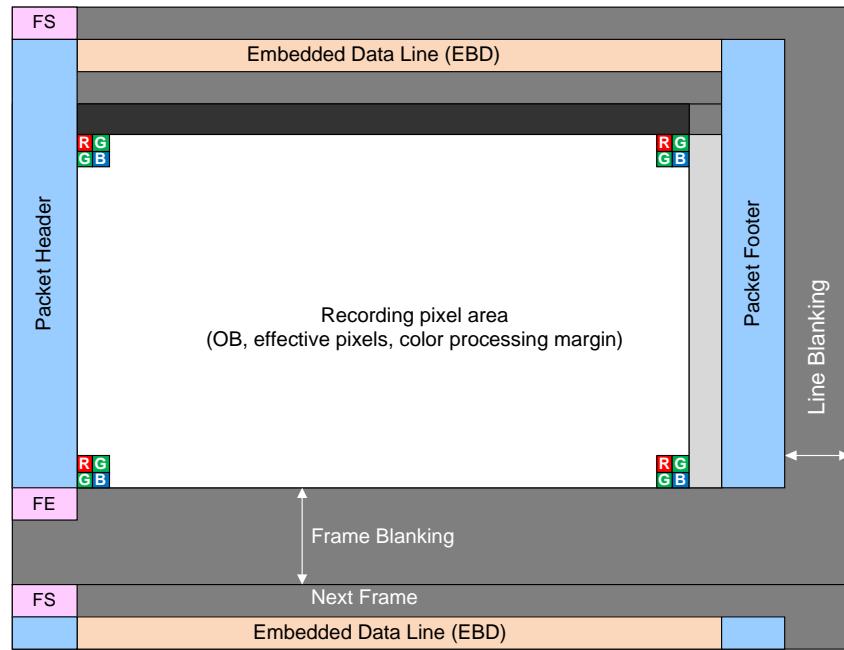
Frame Format

Each line of each image frame is output like the General Frame Format of CSI-2. The settings for each packet header are shown below.

DATA Type

Header [5:0]	Name	Setting register (I ² C)	Description
00h	Frame Start Code	N/A	FS
01h	Frame End Code	N/A	FE
10h	NULL	N/A	Invalid data
12h	Embedded Data	N/A	Embedded data
2Bh	RAW10	Address: 41h, 42h (3441h, 3442h) CSI_DT_FMT [15:0]	0A0Ah
2Ch	RAW12		0C0Ch
37h	OB Data	N/A	Vertical OB line data

Frame Structure



Embedded Data Line

The Embedded data line is output in a line following the sync code FS.

Embedded Data Format



RAW10 (CSI_DT_FMT = 0A0Ah)



RAW12 (CSI_DT_FMT = 0C0Ch)



The end of the address and the register value is determined according to the tags embedded in the data.

Embedded Data Line Tag

Tag	Data Byte Description
00h	Illegal Tag. If found treat as end of Data.
07h	End of Data.
AAh	CCI Register Index MSB [15:8]
A5h	CCI Register Index LSB [7:0]
5Ah	Auto increment the CCI index after the data byte – valid data Data byte contains valid CCI register data.
55h	Auto increment the CCI index after the data byte – null data A CCI register does not exist for the current CCI index. The data byte value is the 07h.
FFh	Illegal Tag. If found treat as end of Data.

Specific output examples are shown below. (4-wire: Chip ID = 05h)

Pixel	Address		Data Byte Description	Value		
	[HEX]					
	4-wire	I ² C				
1	-		Data Format	0Ah		
2			CCI Register Index MSB [15:8]	AAh		
3				33h		
4				A5h		
5			CCI Register Index LSB [7:0]	95h		
6				5Ah		
7	89h	3489h	Fixed to "00h"	00h		
8	8Ah	348Ah		5Ah		
9			REGHOLD value	[0]*		
10				5Ah		
11	8Bh	348Bh	Fixed to "00h"	00h		
12				5Ah		
13	8Ch	348Ch	Fixed to "00h"	00h		
14				5Ah		
15	8Eh	348Eh	Fixed to "90h"	90h		
16				5Ah		
17	8Fh	348Fh	Fixed to "02h"	02h		
18				5Ah		
19	8Dh	348Dh	Fixed to "01h"	01h		
20				5Ah		
21	90h	3490h	Fixed to "01h"	01h		
22				5Ah		
23	91h	3491h	Frame count	[7:0]*		
24				5Ah		
25	B0h	34B0h	Fixed to "01h"	01h		
26			Black level setting value	5Ah		
27	92h	3492h		[7:0]*		
28				5Ah		
29	93h	3493h		[15:8]*		
30			Data format RAW10: 0A0Ah RAW12: 0C0Ch	5Ah		
31	94h	3494h		[7:0]*		
32				5Ah		
33	95h	3495h		[15:8]*		
34			Fixed to "00h"	5Ah		
35	B4h	34B4h		00h		
36			Fixed to "00h"	5Ah		
37	96h	3496h		00h		
38			Fixed to "00h"	5Ah		
39	97h	3497h		00h		
40			Fixed to "2Ch"	5Ah		
41	98h	3498h		2Ch		
42			Fixed to "01h"	5Ah		
43	99h	3499h		01h		
44			Fixed to "03h"	5Ah		
45	9Ah	349Ah		03h		
46			Fixed to "00h"	5Ah		
47	9Bh	349Bh		00h		
48			Fixed to "00h"	5Ah		
49	B8h	34B8h		00h		
50			Fixed to "00h"	5Ah		
51	9Ch	349Ch		00h		
52			Fixed to "00h"	5Ah		
53	9Dh	349Dh		00h		
54			Fixed to "A4h"	5Ah		
55	9Eh	349Eh		A4h		
56			Fixed to "01h"	5Ah		
57	9Fh	349Fh		01h		

Pixel	Address		Data Byte Description	Value		
	[HEX]					
	4-wire	I ² C				
58				5Ah		
59	A0h	34A0h	Fixed to "01h"	01h		
60				5Ah		
61	A1h	34A1h	Fixed to "00h"	00h		
62				5Ah		
63	A2h	34A2h	Fixed to "64h"	64h		
64				5Ah		
65	A3h	34A3h	Fixed to "00h"	00h		
66				5Ah		
67	A4h	34A4h	Fixed to "F0h"	F0h		
68				5Ah		
69	A5h	34A5h	Fixed to "00h"	00h		
70				5Ah		
71	A6h	34A6h	Fixed to "F0h"	F0h		
72				5Ah		
73	A7h	34A7h	Fixed to "00h"	00h		
74				5Ah		
75	A8h	34A8h	Gain Setting Value	[7:0]*		
76				5Ah		
77	A9h	34A9h		[15:8]*		
78				5Ah		
79	AAh	34AAh	Fixed to "00h"	00h		
80				5Ah		
81	ABh	34ABh	Fixed to "00h"	00h		
82				5Ah		
83	ACh	34ACh	Fixed to "00h"	00h		
84				5Ah		
85	ADh	34ADh	Fixed to "00h"	00h		
86			Shutter setting value	5Ah		
87	B1h	34B1h		[7:0]*		
88				5Ah		
89	B2h	34B2h		[15:8]*		
90				5Ah		
91	B3h	34B3h		[23:16]*		
92				5Ah		
93	B5h	34B5h	Fixed to "00h"	00h		
94				5Ah		
95	B6h	34B6h	Fixed to "00h"	00h		
96				5Ah		
97	B7h	34B7h	Fixed to "00h"	00h		
98				5Ah		
99	B9h	34B9h	Fixed to "00h"	00h		
100				5Ah		
101	BAh	34BAh	Fixed to "00h"	00h		
102				5Ah		
103	BBh	34BBh	Fixed to "00h"	00h		
104				5Ah		
105	BDh	34BDh	Fixed to "00h"	00h		
106				5Ah		
107	BEh	34BEh	Fixed to "00h"	00h		
108				5Ah		
109	Bfh	34BFh	Fixed to "00h"	00h		
110				5Ah		
111	C1h	34C1h	Fixed to "00h"	00h		
112				5Ah		
113	C2h	34C2h	Fixed to "00h"	00h		
114				5Ah		
115	C3h	34C3h	Fixed to "00h"	00h		

Pixel	Address		Data Byte Description	Value		
	[HEX]					
	4-wire	I ² C				
116	C5h	34C5h	Fixed to "00h"	5Ah		
117				00h		
118	C6h	34C6h	Fixed to "00h"	5Ah		
119				00h		
120	C7h	34C7h	Fixed to "00h"	5Ah		
121				00h		
122	AEh	34AEh	Fixed to "00h"	5Ah		
123				00h		
124	AFh	34AFh	Fixed to "00h"	5Ah		
125				00h		
126	C9h	34C9h	Vertical line value (VMAX)	5Ah		
127				[7:0]*		
128	CAh	34CAh		5Ah		
129				[15:8]*		
130	CBh	34CBh		5Ah		
131				[23:16]*		
132	CCh	34CCh	Horizontal clock value (HMAX)	5Ah		
133				[7:0]*		
134	CDh	34CDh		5Ah		
135				[15:8]*		
136	CEh	34CEh	Fixed to "00h"	5Ah		
137				00h		
138	CFh	34CFh	Fixed to "00h"	5Ah		
139				00h		
140	D0h	34D0h	Fixed to "00h"	5Ah		
141				00h		
142	D1h	34D1h	Fixed to "00h"	5Ah		
143				00h		
144	D2h	34D2h	Fixed to "9Bh"	5Ah		
145				9Bh		
146	D3h	34D3h	Fixed to "07h"	5Ah		
147				07h		
148	D4h	34D4h	Fixed to "48h"	5Ah		
149				48h		
150	D5h	34D5h	Fixed to "04h"	5Ah		
151				04h		
152	D6h	34D6h	Fixed to "9Ch"	5Ah		
153				9Ch		
154	D7h	34D7h	Fixed to "07h"	5Ah		
155				07h		
156	D8h	34D8h	Fixed to "49h"	5Ah		
157				49h		
158	D9h	34D9h	Fixed to "04h"	5Ah		
159				04h		
160	BCh	34BCh	Fixed to "00h"	5Ah		
161				00h		
162	C0h	34C0h	Fixed to "00h"	5Ah		
163				00h		
164	DAh	34DAh	Fixed to "00h"	5Ah		
165				00h		
166	DBh	34DBh	Fixed to "00h"	5Ah		
167				00h		
168	DCh	34DCh	Fixed to "00h"	5Ah		
169				00h		
170	DDh	34DDh	Fixed to "00h"	5Ah		
171				00h		
172	DEh	34DEh	Fixed to "9Bh"	5Ah		
173				9Bh		

Pixel	Address		Data Byte Description	Value		
	[HEX]					
	4-wire	I ² C				
174	DFh	34DFh	Fixed to "07h"	5Ah		
175				07h		
176	E0h	34E0h	Fixed to "54h"	5Ah		
177				54h		
178	E1h	34E1h	Fixed to "04h"	5Ah		
179				04h		
180	E2h	34E2h	Fixed to "60h"	5Ah		
181				60h		
182	E3h	34E3h	Fixed to "01h"	5Ah		
183				01h		
184	E4h	34E4h	Fixed to "20h"	5Ah		
185				20h		
186	E5h	34E5h	Fixed to "01h"	5Ah		
187				01h		
188	E6h	34E6h	Fixed to "9Ch"	5Ah		
189				9Ch		
190	E7h	34E7h	Fixed to "07h"	5Ah		
191				07h		
192	E8h	34E8h	Fixed to "55h"	5Ah		
193				55h		
194	E9h	34E9h	Fixed to "04h"	5Ah		
195				04h		
196	C4h	34C4h	Fixed to "01h"	5Ah		
197				01h		
198	C8h	34C8h	Number of lane	5Ah		
199				[1:0]*		
200	EAh	34EAh	Fixed to "00h"	5Ah		
201				00h		
202	EBh	34EBh	Fixed to "00h"	5Ah		
203				00h		
204	ECh	34ECh	Fixed to "0Bh"	5Ah		
205				0Bh		
206	EDh	34EDh	Fixed to "00h"	5Ah		
207				00h		
208	EEh	34EEh	Fixed to "0Ch"	5Ah		
209				0Ch		
210	EFh	34EFh	Fixed to "00h"	5Ah		
211				00h		
212	F0h	34F0h	Fixed to "00h"	5Ah		
213				00h		
214	F1h	34F1h	Fixed to "00h"	5Ah		
215				00h		
216	F2h	34F2h	Fixed to "0Bh"	5Ah		
217				0Bh		
218	F3h	34F3h	Fixed to "00h"	5Ah		
219				00h		
220	F4h	34F4h	Fixed to "06h"	5Ah		
221				06h		
222	F5h	34F5h	Fixed to "00h"	5Ah		
223				00h		
224	F6h	34F6h	Fixed to "0Ch"	5Ah		
225				0Ch		
226	F7h	34F7h	Fixed to "00h"	5Ah		
227				00h		
228	F8h			07h		
229				07h		
230				07h		

* The value that shown in Data Byte Description is output.

Image Data Output Format**All-pixel scan mode (Full HD 1080p)**

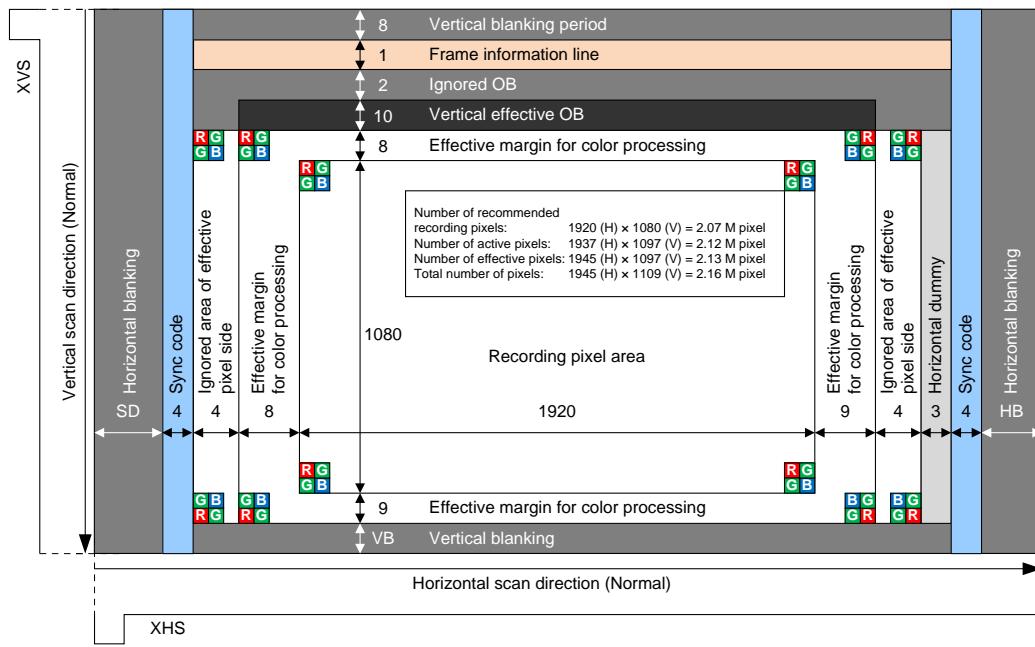
List of Setting Register for CMOS parallel / LVDS serial output

Address		bit	Register Name	Initial Value	CMOS parallel	LVDS serial			Remarks
4-wire	I ² C					2 ch	4 ch	8 ch	
Chip ID: 02h									
05h	3005h	[0]	ADBIT	1h		0h / 1h			0: 10 bit, 1: 12 bit
07h	3007h	[0]	VREVERSE	0h		0h / 1h			0: Normal, 1: Inverted
		[1]	HREVERSE	0h		0h / 1h			0: Normal, 1: Inverted
		[6:4]	WINMODE	0h		0h			Full HD 1080p
09h	3009h	[1:0]	FRSEL	2h		2h			30 / 25 [frame/s]
					N/A	N/A	1h		60 / 50 [frame/s]
					N/A	N/A	N/A	0h	120 / 100 [frame/s]
		[4]	FDG_SEL	0h		0h / 1h			0: LCG mode, 1: HCG mode
12h	3012h	[7:0]	—	F0h		64h			Initial setting
13h	3013h	[7:0]	—	00h		00h			Initial setting
18h	3018h	[7:0]	VMAX	465h					
19h	3019h	[7:0]				465h			25 / 30 / 50 / 60 / 100 / 120 [frame/s]
1Ah	301Ah	[1:0]							
1Ch	301Ch	[7:0]				1130h / 14A0h			1130h : 30[frame/s] / 14A0h : 25[frame/s]
1Dh	301Dh	[7:0]	HMAX	1130h	N/A	N/A	0898h / 0A50h		0898h : 60[frame/s] / 0A50h : 50[frame/s]
					N/A	N/A	N/A	044Ch / 0528h	044Ch : 120[frame/s] / 0528h : 100[frame/s]
46h	3046h	[1:0]	ODBIT	1h	0h / 1h				0: 10 bit, 1: 12 bit
		[7:4]	OPORTSEL	0h	0h	Dh	Eh	Fh	I/F selection
5Ch	305Ch	[7:0]	INCKSEL1	0Ch	0Ch / 18h				Set according to INCK 74.25 / 37.125 MHz
5Dh	305Dh	[7:0]	INCKSEL2	00h	00h / 00h				
5Eh	305Eh	[7:0]	INCKSEL3	10h	10h / 20h				
5Fh	305Fh	[7:0]	INCKSEL4	01h	01h / 10h				
Chip ID = 03h									
29h	3129h	[7:0]	ADBIT1	00h	1Dh / 00h				10bit : 1Dh 12bit : 00h
5Eh	315Eh	[7:0]	INCKSEL5	1Bh	1Bh / 1Ah				INCK : 74.25 / 37.125 MHz
64h	3164h	[7:0]	INCKSEL6	1Bh	1Bh / 1Ah				INCK : 74.25 / 37.125 MHz
7Ch	317Ch	[7:0]	ADBIT2	17h	12h / 00h				10bit : 12h 12bit : 00h
ECh	31ECh	[7:0]	ADBIT3	0Eh	37h / 0Eh				10bit : 37h 12bit : 0Eh
Chip ID = 04h									
00h	3200h	[7:0]	to	to	Set register value that described on item "Register map".				
FFh	32FFh	[7:0]							
ChipID = 05h									
00h	3300h	[7:0]	to	to	Set register value that described on item "Register map".				
FFh	33FFh	[7:0]							
ChipID = 06h									
00h	3400h	[7:0]	to	to	Changing the value is not necessary.				
FFh	34FFh	[7:0]							

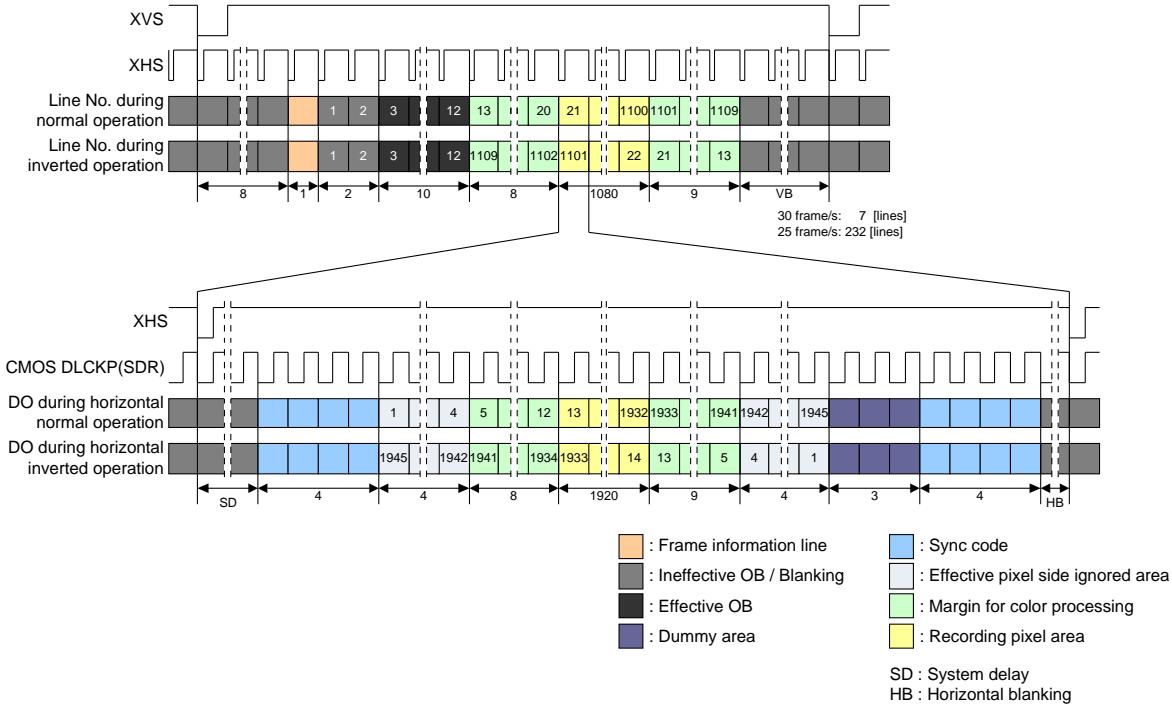
List of Setting Register for CSI-2 serial output

Address		bit	Register Name	Initial Value	CSI-2 serial						Remarks									
					2 lane		4 lane													
4-wire	I ² C				30 / 25 [frame / s]	60 / 50 [frame / s]	30 / 25 [frame / s]	60 / 50 [frame / s]	120 / 100 [frame / s]											
Chip ID: 02h																				
05h	3005h	[0]	ADBIT	1h	0h / 1h						0: 10 bit, 1: 12 bit									
07h	3007h	[0]	VREVERSE	0h	0h / 1h						0: Normal, 1: Inverted									
		[1]	HREVERSE	0h	0h / 1h						0: Normal, 1: Inverted									
		[6:4]	WINMODE	0h	0h						Full HD 1080p									
		[1:0]	FRSEL	2h	2h	1h	2h	1h	0h											
09h	3009h	[4]	FDG_SEL	0h	0h / 1h						0: LCG mode, 1: HCG mode									
		[7:0]	—	F0h	64h						Initial setting									
12h	3012h	[7:0]	—	00h	00h						Initial setting									
18h	3018h	[7:0]	VMAX	465h	465h						25 / 30 / 50 / 60 / 100 / 120 [frame/s]									
19h	3019h	[7:0]			465h															
1Ah	301Ah	[1:0]			1130h / 14A0h						30 / 60 / 120 [frame / s] / 25 / 50 / 100 [frame / s]									
1Ch	301Bh	[7:0]			0898h / 0A50h															
1Dh	301Ch	[7:0]	HMAX	1130h	1130h / 14A0h	0898h / 0A50h	1130h / 14A0h	0898h / 0A50h	044Ch / 0528h											
46h	3046h	[1:0]	ODBIT	1h	1h						In CSI-2, fixed to "1h".									
		[7:4]	OPORTSEL	0h	0h						In CSI-2, fixed to "0h".									
5Ch	305Ch	[7:0]	INCKSEL1	0Ch	0Ch / 18h															
5Dh	305Dh	[7:0]	INCKSEL2	00h	03h / 03h						Set according to INCK									
5Eh	305Eh	[7:0]	INCKSEL3	10h	10h / 20h						74.25 / 37.125 MHz									
5Fh	305Fh	[7:0]	INCKSEL4	01h	01h / 01h															
Chip ID = 03h																				
29h	3129h	[7:0]	ADBIT1	00h	1Dh / 00h						10bit : 1Dh 12bit : 00h									
5Eh	315Eh	[7:0]	INCKSEL5	1Bh	1Bh / 1Ah						Set according to INCK									
64h	3164h	[7:0]	INCKSEL6	1Bh	1Bh / 1Ah						74.25 / 37.125 MHz									
7Ch	317Ch	[7:0]	ADBIT2	17h	12h / 00h						10bit : 12h 12bit : 00h									
ECh	31ECh	[7:0]	ADBIT3	0Eh	37h / 0Eh						10bit : 37h 12bit : 0Eh									
Chip ID = 04h																				
00h	3200h	[7:0]	Set register value that described on item "Register map".																	
FFh	to	32FFh	[7:0]																	
00h	3300h	[7:0]	Set register value that described on item "Register map".																	
FFh	to	33FFh	[7:0]																	

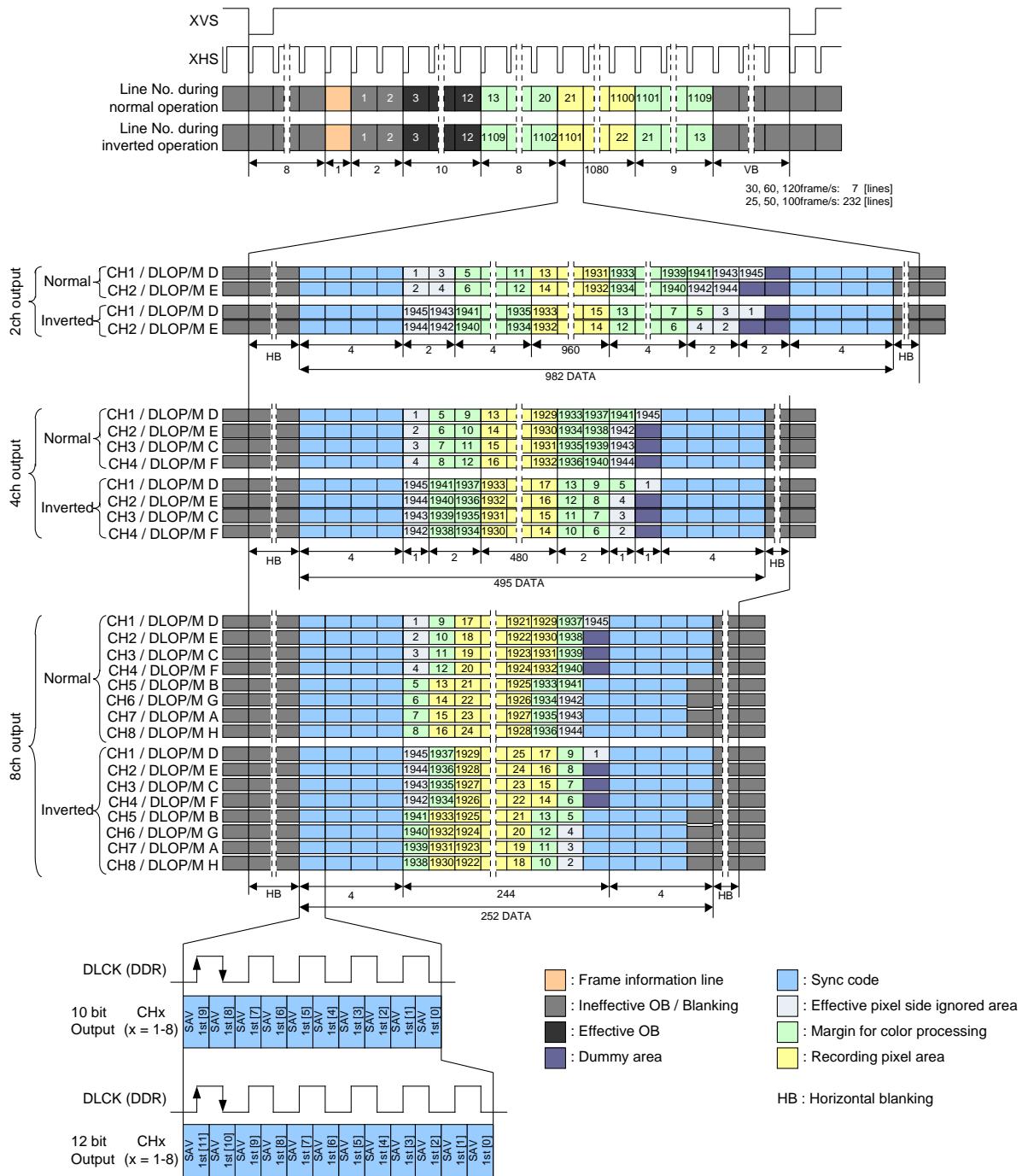
Address		bit	Register Name	Initial Value	CSI-2 serial					Remarks			
					2 lane		4 lane						
4-wire	I ² C				30 / 25 [frame /s]	60 / 50 [frame /s]	30 / 25 [frame /s]	60 / 50 [frame /s]	120 / 100 [frame /s]				
Chip ID = 06h													
				Data rate		445.5	891	222.75	445.5	891			
05h	3405h	[5:4]	REPETITION	2h	1h	0h	2h	1h	0h				
07h	3407h	[1:0]	PHYSICAL_LANE_NUM	3h	1h		3h						
14h	3414h	[5:0]	OPB_SIZE_V	Ah	Ah								
18h	3418h	[7:0]	Y_OUT_SIZE	0449h	0449h								
19h	3419h	[4:0]											
41h	3441h	[7:0]	CSI_DT_FMT	0C0Ch	0A0Ah / 0C0Ch					0A0Ah: RAW10 0C0Ch: RAW12			
42h	3442h	[7:0]	CSI_LANE_MODE	3h	1h		3h						
43h	3443h	[1:0]											
44h	3444h	[7:0]	EXTCK_FREQ	4A40h	37.125 MHz: 2520h 74.25 MHz: 4A40h								
45h	3445h	[7:0]											
46h	3446h	[7:0]	TCLKPOST	047h	057h	077h	047h	057h	077h	Global timing			
47h	3447h	[0]	THSZERO	01Fh	037h	067h	01Fh	037h	067h	Global timing			
48h	3448h	[7:0]											
49h	3449h	[0]	THSPREPARE	017h	01Fh	047h	017h	01Fh	047h	Global timing			
4Ah	344Ah	[7:0]											
4Bh	344Bh	[0]	TCLKTRAIL	00Fh	01Fh	037h	00Fh	01Fh	037h	Global timing			
4Ch	344Ch	[7:0]											
4Dh	344Dh	[0]	THSTRAIL	017h	01Fh	03Fh	017h	01Fh	03Fh	Global timing			
4Eh	344Eh	[7:0]											
4Fh	344Fh	[0]	TCLKZERO	047h	077h	0FFh	047h	077h	0FFh	Global timing			
50h	3450h	[7:0]											
51h	3451h	[0]	TCLKPREPAR	00Fh	01Fh	03Fh	00Fh	01Fh	03Fh	Global timing			
52h	3452h	[7:0]											
53h	3453h	[0]	TLPX	00Fh	017h	037h	00Fh	017h	037h	Global timing			
54h	3454h	[7:0]											
55h	3455h	[0]	X_OUT_SIZE	079Ch	079Ch								
72h	3472h	[7:0]											
73h	3473h	[4:0]											



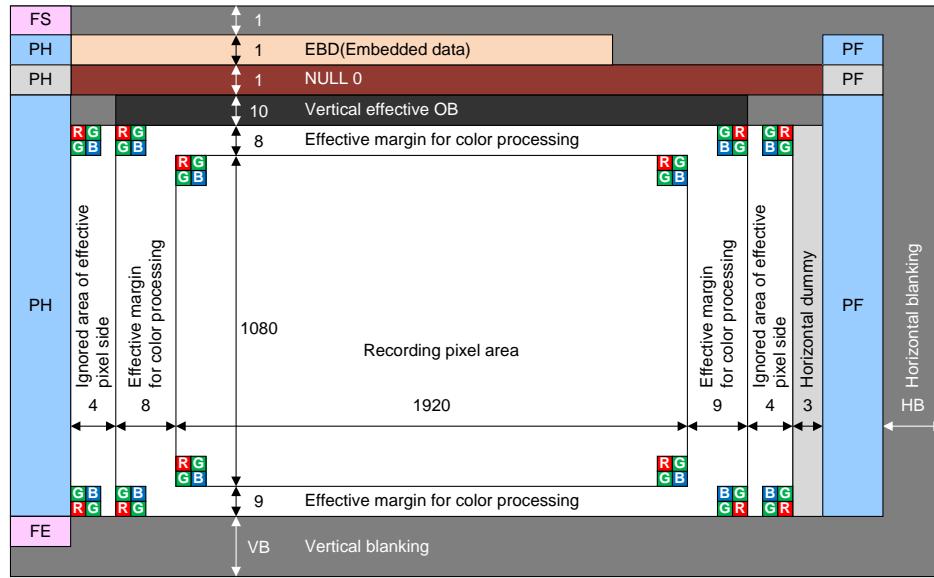
Pixel Array Image Drawing in Full HD 1080p mode (Parallel CMOS output / Serial LVDS output)



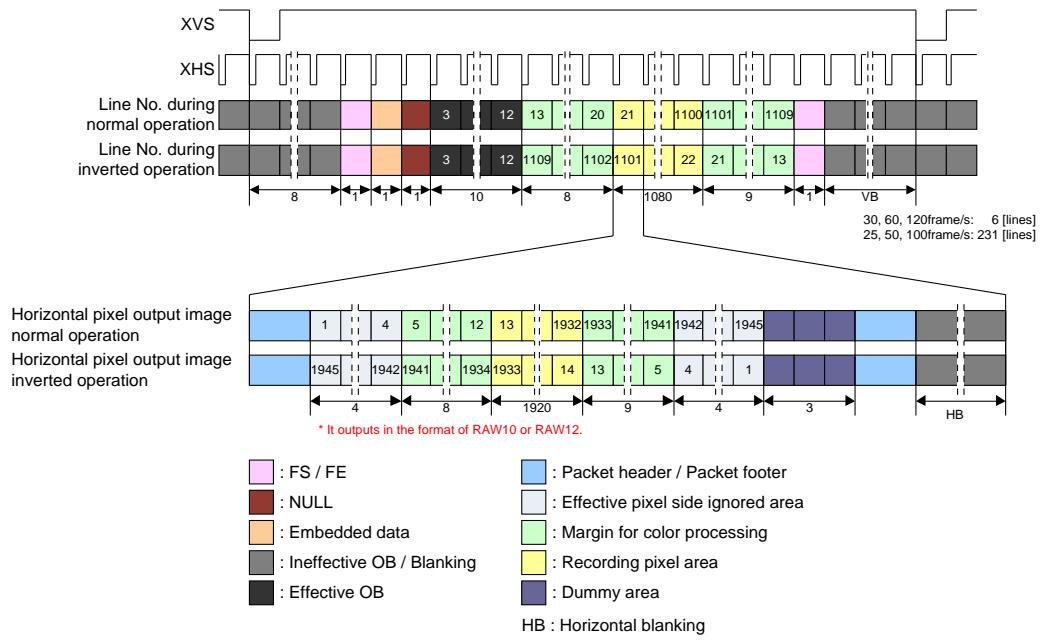
Drive Timing Chart for Full HD 1080p mode (Parallel CMOS output)



Drive Timing Chart for Full HD 1080p mode (Serial LVDS output)



Pixel Array Image Drawing in Full HD 1080p mode (CSI-2 serial output)



Drive Timing Chart for Full HD 1080p mode (CSI-2 serial output)

Window Cropping Mode

Sensor signals are cut out and read out in arbitrary positions.

Cropping position is set, regarding effective pixel start position as origin (0, 0) in all pixel scan mode. Cropping is available from all-pixel scan mode and vertical, horizontal period and frame rate are fixed to the value for this mode. Pixels cropped by horizontal cropping setting are output with left justified and that extends the horizontal blanking period.

Window cropping image is shown in the figure below.

Cropping position is set, regarding effective pixel start position as origin (0, 0) in all pixel scan mode. Only vertical width can be set for OB (horizontal width is the same as the Window cropping width).

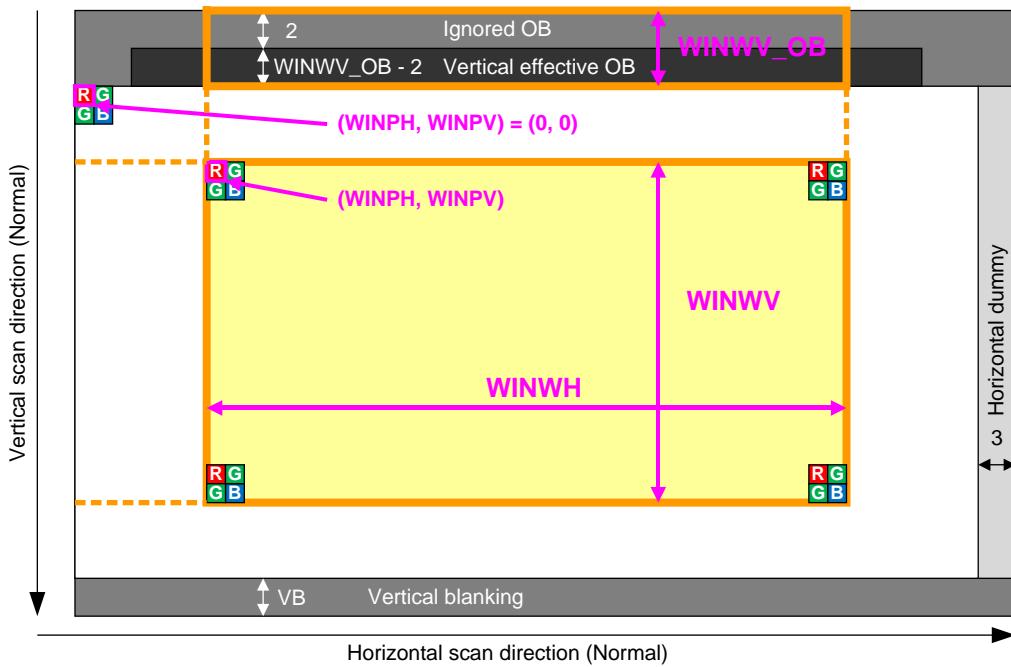


Image Drawing of Window Cropping Mode

Restrictions on Window cropping mode

The register settings should satisfy following conditions:

$$\text{WINPH} + \text{WINWH} \leq 1944$$

$$368 \leq \text{WINWH}$$

Set WINPH and WINWH to a multiple of 4.

$$V_{TTL} \text{ (Number of lines per frame or VMAX)} \geq \text{WINWV_OB} + \text{WINWV} + 13$$

However,

$$6 \leq \text{WINWV_OB} \leq 12$$

$$\text{WINPV} + \text{WINWV} \leq 1096$$

$$304 \leq \text{WINWV}$$

$$\text{OB_SIZE_V} = \text{WINWV_OB} - 2 \text{ (In CSI-2 output)}$$

$$\text{Y_OUT_SIZE} = \text{WINWV} \text{ (In CSI-2 output)}$$

Frame rate on Window cropping mode

$$\text{Frame rate [frame/s]} = 1 / (V_{TTL} \times (1\text{H period}))$$

1H period (unit: [μ s]) : Fix 1H time in a mode before cropping and calculate it by the value of "Number of INCK in 1H" in the table of "Operating Mode" and "List of Operation Modes and Output Rates".

List of Setting Register for CMOS parallel / LVDS serial output

Address		bit	Register Name	Initial Value	CMOS parallel	LVDS serial			Remarks			
4-wire	I ² C					2 ch	4 ch	8 ch				
Chip ID: 02h												
05h	3005h	[0]	ADBIT	1h		0h / 1h			0: 10 bit, 1: 12 bit			
07h	3007h	[0]	VREVERSE	0h		0h / 1h			0: Normal, 1: Inverted			
		[1]	HREVERSE	0h		0h / 1h			0: Normal, 1: Inverted			
		[6:4]	WINMODE	0h		4h			Window cropping			
		[1:0]	FRSEL	2h	2h							
09h	3009h				N/A	N/A	1h					
					N/A	N/A	N/A	0h				
					[4]	FDG_SEL	0h / 1h					
					0h		0: LCG mode, 1: HCG mode					
12h	3012h	[7:0]	—	F0h		64h			Initial setting			
13h	3013h	[7:0]	—	00h		00h			Initial setting			
18h	3018h	[7:0]	VMAX	465h	V _{TTL}				See previous page.			
19h	3019h	[7:0]										
1Ah	301Ah	[1:0]										
1Ch	301Ch	[7:0]										
1Dh	301Dh	[7:0]	HMAX	1130h	1130h / 14A0h				1130h : 30[frame/s] / 14A0h : 25[frame/s]			
					N/A	N/A	0898h / 0A50h		0898h : 60[frame/s] / 0A50h : 50[frame/s]			
					N/A	N/A	N/A	044Ch / 0528h	044Ch : 120[frame/s] / 0528h : 100[frame/s]			
46h	3046h	[1:0]	ODBIT	1h	0h / 1h				0: 10 bit, 1: 12 bit			
		[7:4]	OPORTSEL	0h	0h	Dh	Eh	Fh	I/F selection			
5Ch	305Ch	[7:0]	INCKSEL1	0Ch	0Ch / 18h				Set according to INCK 74.25/37.125 MHz			
5Dh	305Dh	[7:0]	INCKSEL2	00h	00h / 00h							
5Eh	305Eh	[7:0]	INCKSEL3	10h	10h / 20h							
5Fh	305Fh	[7:0]	INCKSEL4	01h	01h / 01h							
Chip ID = 03h												
29h	3129h	[7:0]	ADBIT1	00h	1Dh / 00h				10bit : 1Dh 12bit : 00h			
5Eh	315Eh	[7:0]	INCKSEL5	1Bh	1Bh / 1Ah				INCK : 74.25 / 37.125 MHz			
64h	3164h	[7:0]	INCKSEL6	1Bh	1Bh / 1Ah				INCK : 74.25 / 37.125 MHz			
7Ch	317Ch	[7:0]	ADBIT2	17h	12h / 00h				10bit : 12h 12bit : 00h			
ECh	31ECh	[7:0]	ADBIT3	0Eh	37h / 0Eh				10bit : 37h 12bit : 0Eh			
Chip ID = 04h												
00h	3200h	[7:0]	to	to	Set register value that described on item "Register map".							
FFh	32FFh	[7:0]										
ChipID = 05h												
00h	3300h	[7:0]	to	to	Set register value that described on item "Register map".							
FFh	33FFh	[7:0]										
ChipID = 06h												
00h	3400h	[7:0]	to	to	Changing the value is not necessary.							
FFh	34FFh	[7:0]										

List of Setting Register for CSI-2 serial output

Address		bit	Register Name	Initial Value	CSI-2 serial					Remarks					
					2 lane		4 lane								
4-wire	I ² C				*1 [frame /s]	*2 [frame /s]	*1 [frame /s]	*2 [frame /s]	*3 [frame /s]						
Chip ID: 02h															
05h	3005h	[0]	ADBIT	1h	0h / 1h					0: 10 bit, 1: 12 bit					
07h	3007h	[0]	VREVERSE	0h	0h / 1h					0: Normal, 1: Inverted					
		[1]	HREVERSE	0h	0h / 1h					0: Normal, 1: Inverted					
		[6:4]	WINMODE	0h	4h					Window cropping					
09h	3009h	[1:0]	FRSEL	2h	2h	1h	2h	1h	0h	0: LCG mode, 1: HCG mode					
		[4]	FDG_SEL	0h	0h / 1h										
12h	3012h	[7:0]	—	F0h	64h					Initial setting					
13h	3013h	[7:0]	—	00h	00h					Initial setting					
18h	3018h	[7:0]	VMAX	465h	V _{TTL}					See previous page.					
19h	3019h	[7:0]													
1Ah	301Ah	[1:0]	HMAX	1130h	1130h / 14A0h	0898h / 0A50h	1130h / 14A0h	0898h / 0A50h	044Ch / 0528h	465h: 30 / 60 / 120 [frame / s] / 546h: 25 / 50 / 100 [frame / s]					
1Ch	301Bh	[7:0]													
1Dh	301Ch	[7:0]													
46h	3046h	[1:0]	ODBIT	1h	1h					In CSI-2, fixed to "1h".					
		[7:4]	OPORTSEL	0h	0h					In CSI-2, fixed to "0h".					
5Ch	305Ch	[7:0]	INCKSEL1	0Ch	0Ch / 18h					Set according to INCK 74.25 / 37.125 MHz					
5Dh	305Dh	[7:0]	INCKSEL2	00h	00h / 03h										
5Eh	305Eh	[7:0]	INCKSEL3	10h	10h / 20h										
5Fh	305Fh	[7:0]	INCKSEL4	01h	01h / 01h										
Chip ID = 03h															
29h	3129h	[7:0]	ADBIT1	00h	1Dh / 00h					10bit : 1Dh 12bit : 00h					
5Eh	315Eh	[7:0]	INCKSEL5	1Bh	1Bh / 1Ah					Set according to INCK 74.25 / 37.125 MHz					
64h	3164h	[7:0]	INCKSEL6	1Bh	1Bh / 1Ah					Set according to INCK 74.25 / 37.125 MHz					
7Ch	317Ch	[7:0]	ADBIT2	17h	12h / 00h					10bit : 12h 12bit : 00h					
ECh	31ECh	[7:0]	ADBIT3	0Eh	37h / 0Eh					10bit : 37h 12bit : 0Eh					
Chip ID = 04h															
00h to FFh	3200h to 32FFh	[7:0] [7:0]	Set register value that described on item "Register map".												
Chip ID = 05h															
00h to FFh	3300h to 33FFh	[7:0] [7:0]	Set register value that described on item "Register map".												

Address		bit	Register Name	Initial Value	CSI-2 serial					Remarks			
					2 lane		4 lane						
4-wire	I ² C				*1 [frame /s]	*2 [frame /s]	*1 [frame /s]	*2 [frame /s]	*3 [frame /s]				
Chip ID = 06h													
				Data rate		445.5	891	222.75	445.5	891			
05h	3405h	[5:4]	REPETITION	2h	1h	0h	2h	1h	0h				
07h	3407h	[1:0]	PHYSICAL_LANE_NUM	3h	1h		3h						
14h	3414h	[5:0]	OPB_SIZE_V	Ah	Ah								
18h	3418h	[7:0]	Y_OUT_SIZE	0449h	0449h								
19h	3419h	[4:0]											
41h	3441h	[7:0]	CSI_DT_FMT	0C0Ch	0A0Ah / 0C0Ch					0A0Ah: RAW10 0C0Ch: RAW12			
42h	3442h	[7:0]	CSI_LANE_MODE	3h	1h		3h						
43h	3443h	[1:0]											
44h	3444h	[7:0]	EXTCK_FREQ	4A40h	37.125 MHz: 2520h 74.25 MHz: 4A40h								
45h	3445h	[7:0]											
46h	3446h	[7:0]	TCLKPOST	047h	057h	077h	047h	057h	077h	Global timing			
47h	3447h	[0]	THSZERO	01Fh	037h	067h	01Fh	037h	067h	Global timing			
48h	3448h	[7:0]											
49h	3449h	[0]	THSPREPARE	017h	01Fh	047h	017h	01Fh	047h	Global timing			
4Ah	344Ah	[7:0]											
4Bh	344Bh	[0]	TCLKTRAIL	00Fh	01Fh	037h	00Fh	01Fh	037h	Global timing			
4Ch	344Ch	[7:0]											
4Dh	344Dh	[0]	THSTRAIL	017h	01Fh	03Fh	017h	01Fh	03Fh	Global timing			
4Eh	344Eh	[7:0]											
4Fh	344Fh	[0]	TCLKZERO	047h	077h	0FFh	047h	077h	0FFh	Global timing			
50h	3450h	[7:0]											
51h	3451h	[0]	TCLKPREPARE	00Fh	01Fh	03Fh	00Fh	01Fh	03Fh	Global timing			
52h	3452h	[7:0]											
53h	3453h	[0]	TLPX	00Fh	017h	037h	00Fh	017h	037h	Global timing			
54h	3454h	[7:0]											
55h	3455h	[0]	X_OUT_SIZE	079Ch	079Ch								
72h	3472h	[7:0]											
73h	3473h	[4:0]											

The example of window cropping setting is shown below.

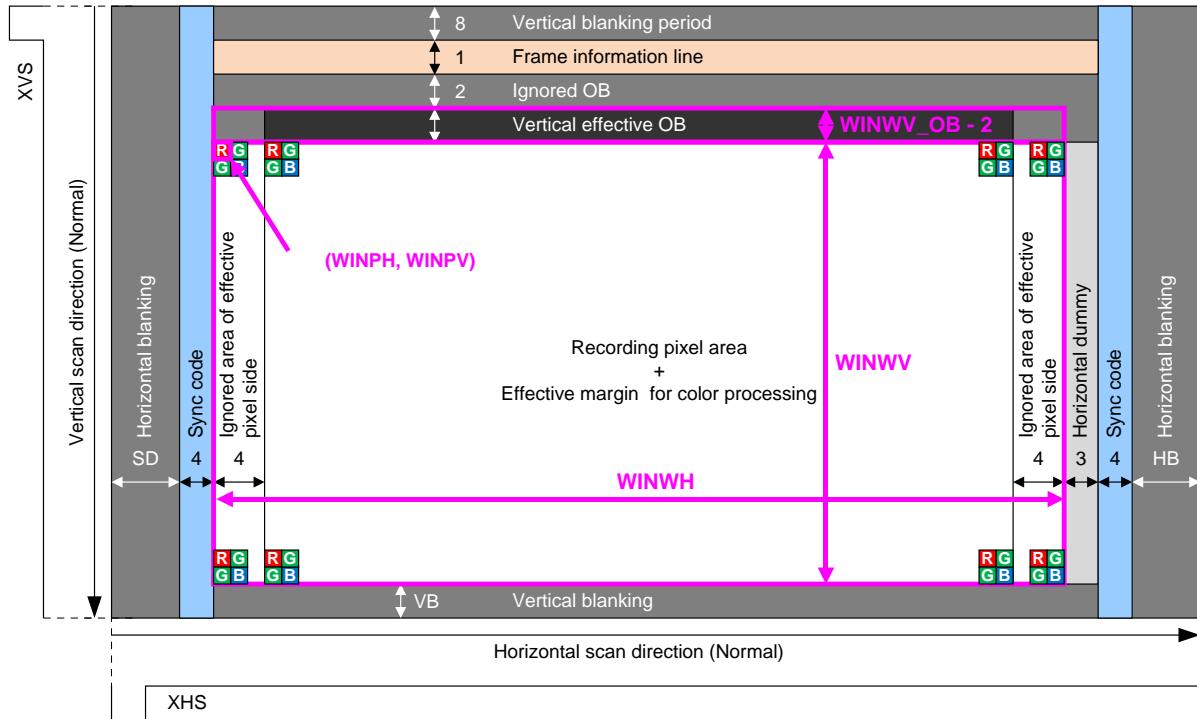
The frame rate is maximum setting as each image format. For adjust the frame rate, please extend the VMAX or the number of lines per frame.

Example of Window cropping Mode Setting

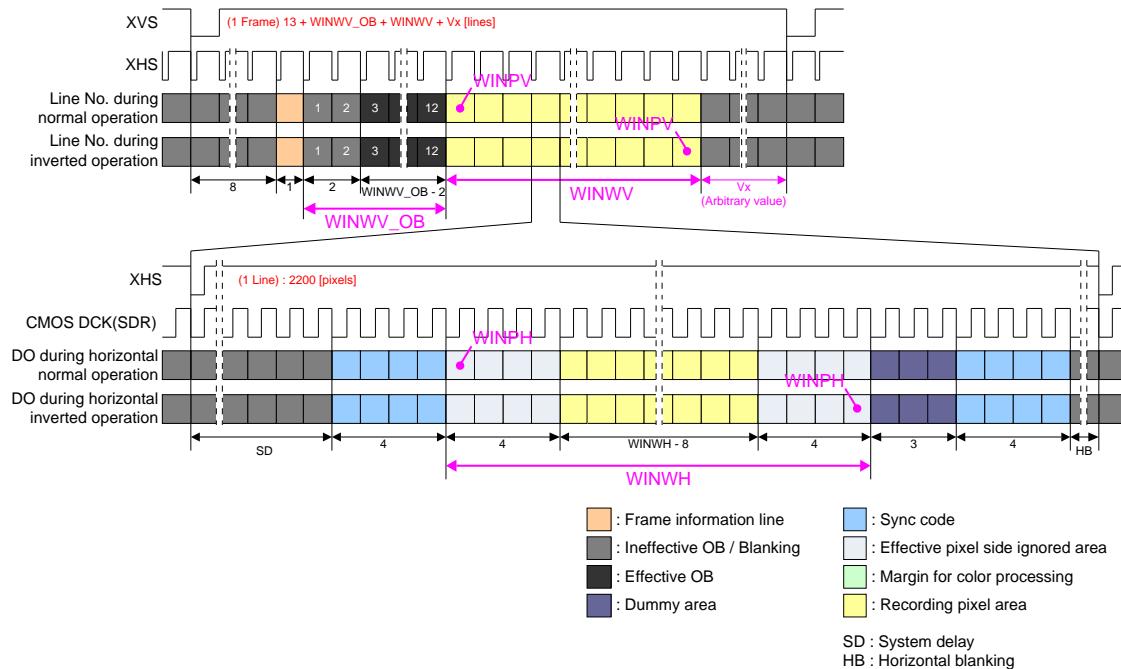
Image size	INCK [MHz]	Output Resolution [bit]	Frame rate [frame/s]	Number of recording pixels		Register setting [DEC] (HEX)						
				Horizontal	Vertical	FRSEL	HMAX	VMAX	WINPH	WINPV	WINWH	WINWV
VGA	37.125 74.25	10/12	64.9	640	480	2	4400d (1130h)	520d (208h)	640d (280h)	300d (12Ch)	656d (290h)	496d (1F0h)
		10/12	129.8			1	2200d (898h)					
		10	259.6			0	1100d (44Ch)					
CIF	37.125 74.25	10/12	102.9	352	288	2	4400d (1130h)	328d (148h)	784d (310h)	396d (18Ch)	368d (170h)	304d (130h)
		10/12	205.8			1	2200d (898h)					
		10	411.6			0	1100d (44Ch)					

* These settings are when the ignored OB line is 2 lines and effective OB line is 10 lines.

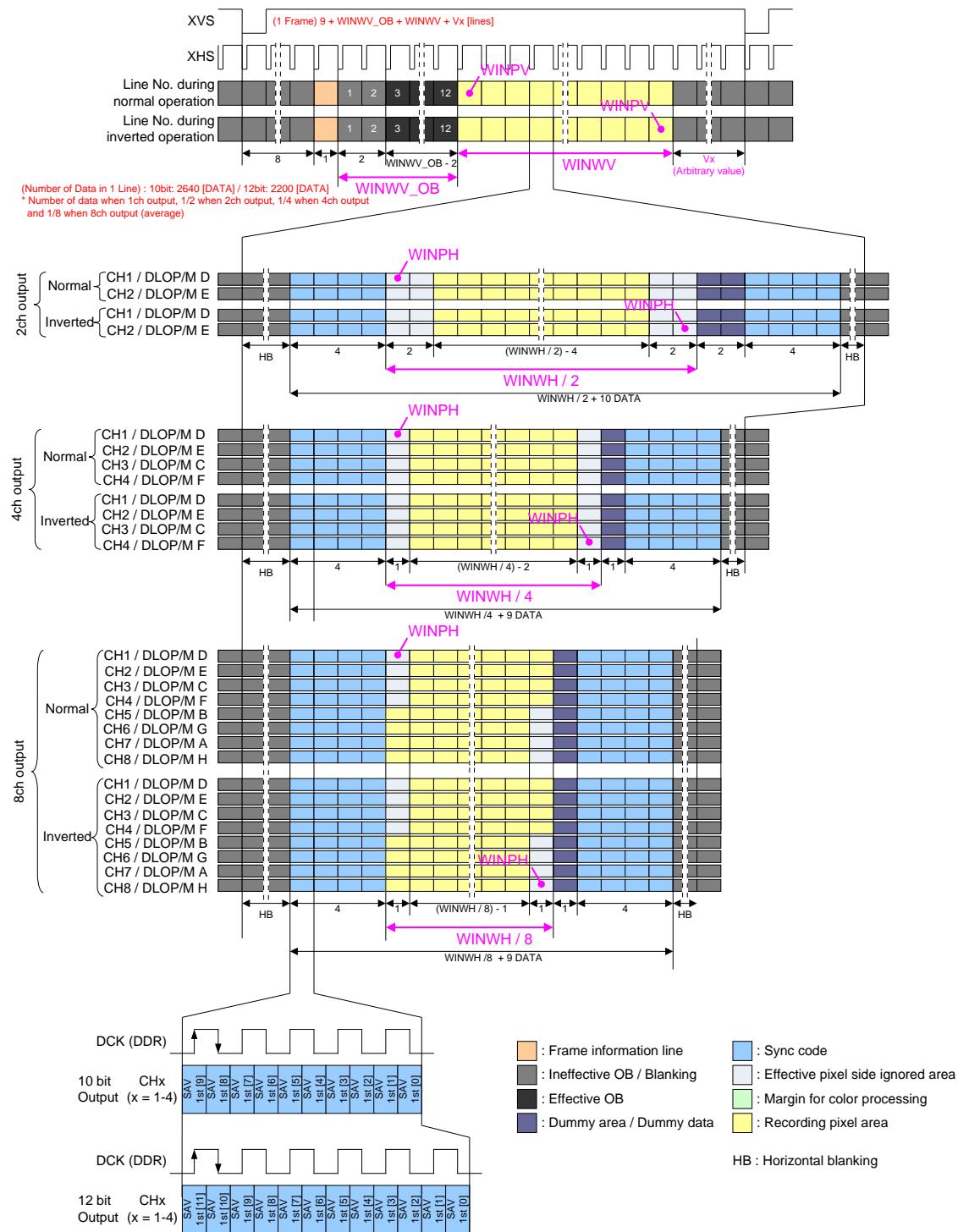
* When the CSI-2 output, set the value that is set to register WINWV_OB to register Y_OUT_SIZE.



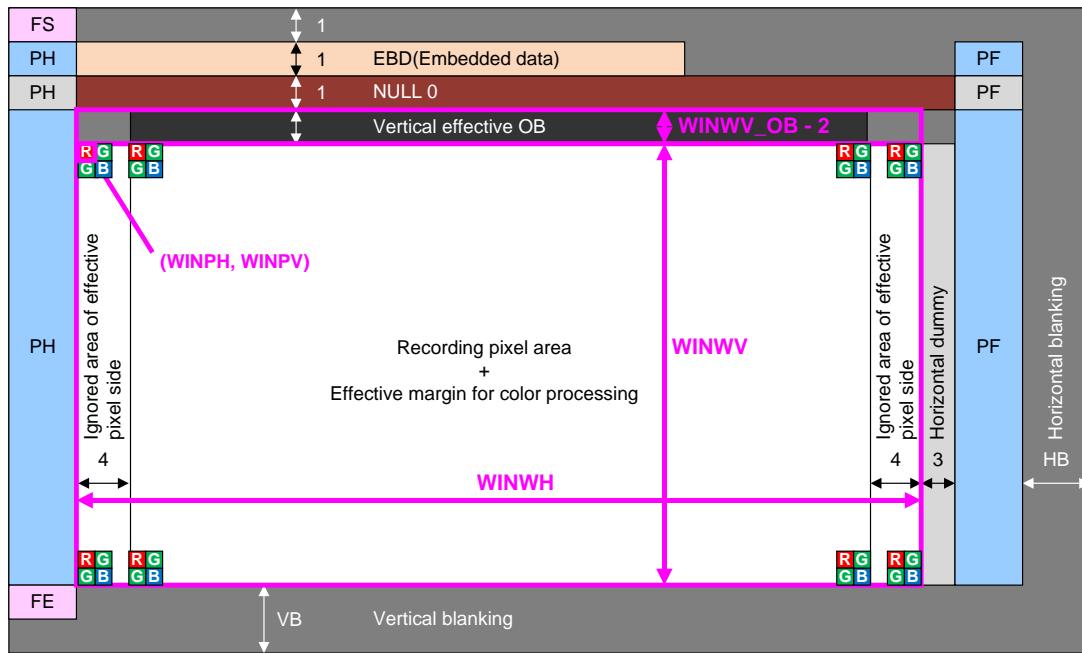
Pixel Array Image Drawing in Window Cropping mode (Parallel CMOS output / Serial LVDS output)



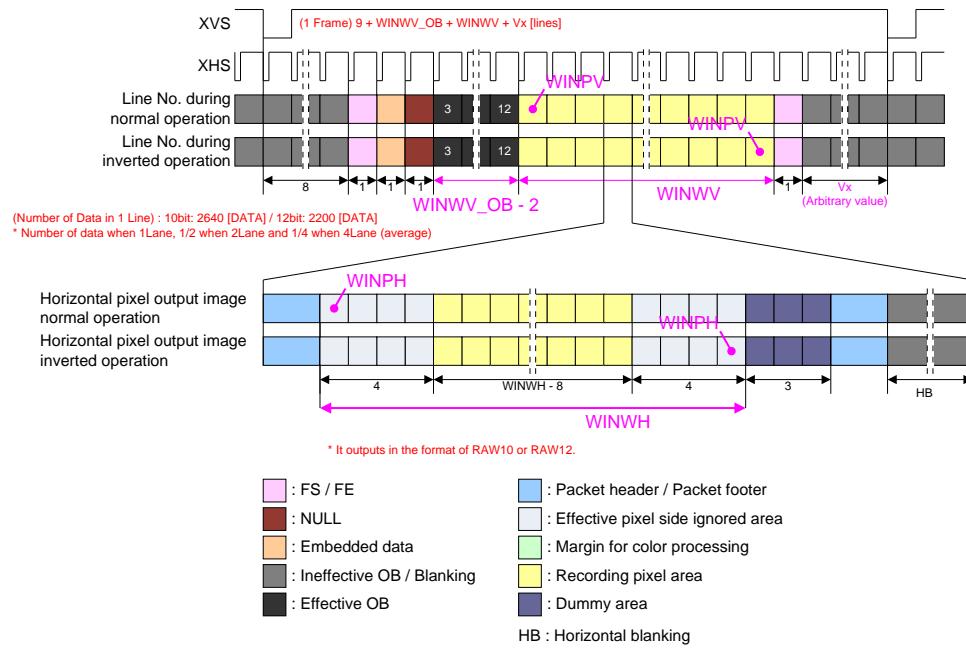
Drive Timing Chart for Window Cropping mode (Parallel CMOS output)



Drive Timing Chart for Window Cropping mode (Serial LVDS output)



Pixel Array Image Drawing in Window Cropping mode (CSI-2 serial output)



Drive Timing Chart for Window Cropping mode (CSI-2 serial output)

HD720p mode

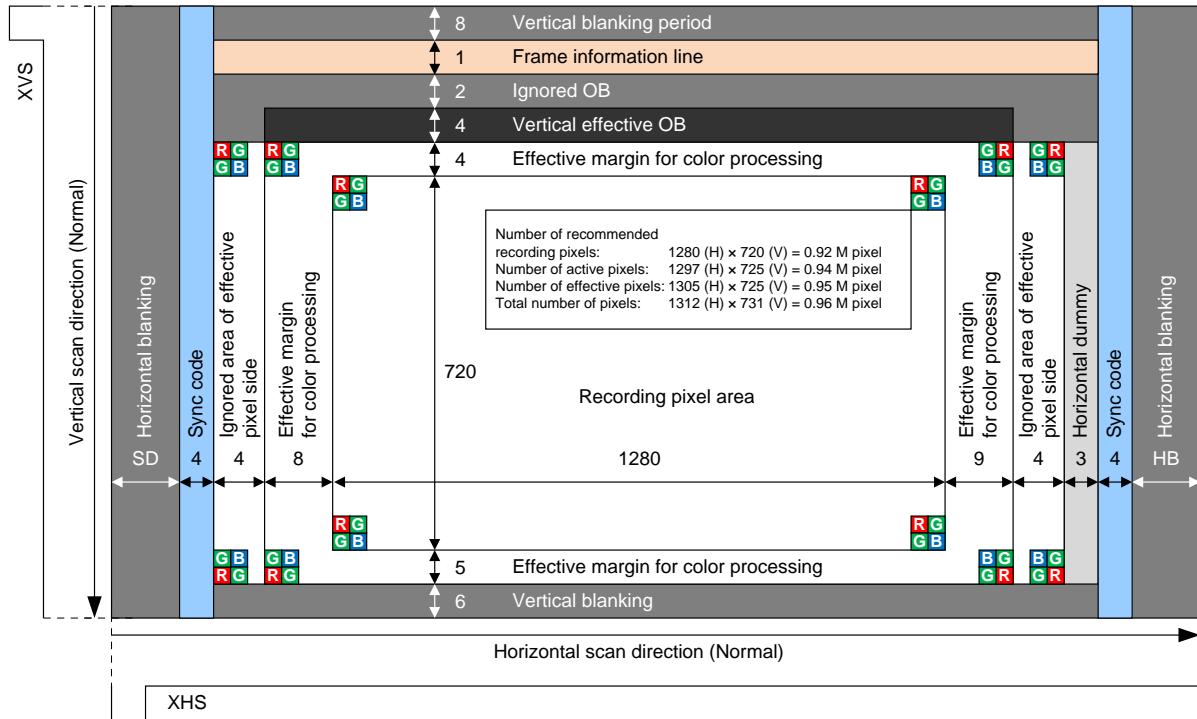
List of Setting Register for CMOS parallel / LVDS serial output

Address		bit	Register Name	Initial Value	CMOS parallel	LVDS serial		Remarks			
4-wire	I ² C					2 ch	4 ch				
Chip ID: 02h											
05h	3005h	[0]	ADBIT	1h		0h / 1h		0: 10 bit, 1: 12 bit			
07h	3007h	[0]	VREVERSE	0h		0h / 1h		0: Normal, 1: Inverted			
		[1]	HREVERSE	0h		0h / 1h		0: Normal, 1: Inverted			
		[6:4]	WINMODE	0h		1h		HD 720p			
		[1:0]	FRSEL	2h	2h			30 [frame/s]			
09h	3009h				1h			60 [frame/s]			
					N/A	N/A	0h	120 [Frame/s]			
	[4]	FDG_SEL	0h		0h / 1h		0: LCG mode, 1: HCG mode				
12h	3012h	[7:0]	—	F0h		64h		Initial setting			
13h	3013h	[7:0]	—	00h		00h		Initial setting			
18h	3018h	[7:0]	VMAX	465h		2EEh		25 /30 / 50 / 60 / 100 / 120 [frame/s]			
19h	3019h	[7:0]									
1Ah	301Ah	[1:0]									
1Ch	301Ch	[7:0]				19C8h / 1EF0h		19C8h : 30[frame/s] / 1EF0h : 25[frame/s]			
1Dh	301Dh	[7:0]	HMAX	1130h		0CE4h / 0F78h		0CE4h : 60[frame/s] / 0F78h : 50[frame/s]			
					N/A	N/A	0672h / 07BCh	0672h : 120[frame/s] / 07BCh : 100[frame/s]			
46h	3046h	[1:0]	ODBIT	1h		0h / 1h		0: 10 bit, 1: 12 bit			
		[7:4]	OPORTSEL	0h	0h	Dh	Eh	I/F selection			
5Ch	305Ch	[7:0]	INCKSEL1	0Ch		10h / 20h		Set according to INCK 74.25/37.125 MHz			
5Dh	305Dh	[7:0]	INCKSEL2	00h		00h / 00h					
5Eh	305Eh	[7:0]	INCKSEL3	10h		10h / 20h					
5Fh	305Fh	[7:0]	INCKSEL4	01h		01h / 01h					
Chip ID = 03h											
29h	3129h	[7:0]	ADBIT1	00h		1Dh / 00h		10bit : 1Dh 12bit : 00h			
5Eh	315Eh	[7:0]	INCKSEL5	1Bh		1Bh / 1Ah		INCK : 74.25 / 37.125 MHz			
64h	3164h	[7:0]	INCKSEL6	1Bh		1Bh / 1Ah		INCK : 74.25 / 37.125 MHz			
7Ch	317Ch	[7:0]	ADBIT2	17h		12h / 00h		10bit : 12h 12bit : 00h			
ECh	31ECh	[7:0]	ADBIT3	0Eh		37h / 0Eh		10bit :37h 12bit : 0Eh			
Chip ID = 04h											
00h to FFh	3200h to 32FFh	[7:0] [7:0]				Set register value that described on item "Register map".					
ChipID = 05h											
00h to FFh	3300h to 33FFh	[7:0] [7:0]				Set register value that described on item "Register map".					
ChipID = 06h											
00h to FFh	3400h to 34FFh	[7:0] [7:0]				Changing the value is not necessary.					

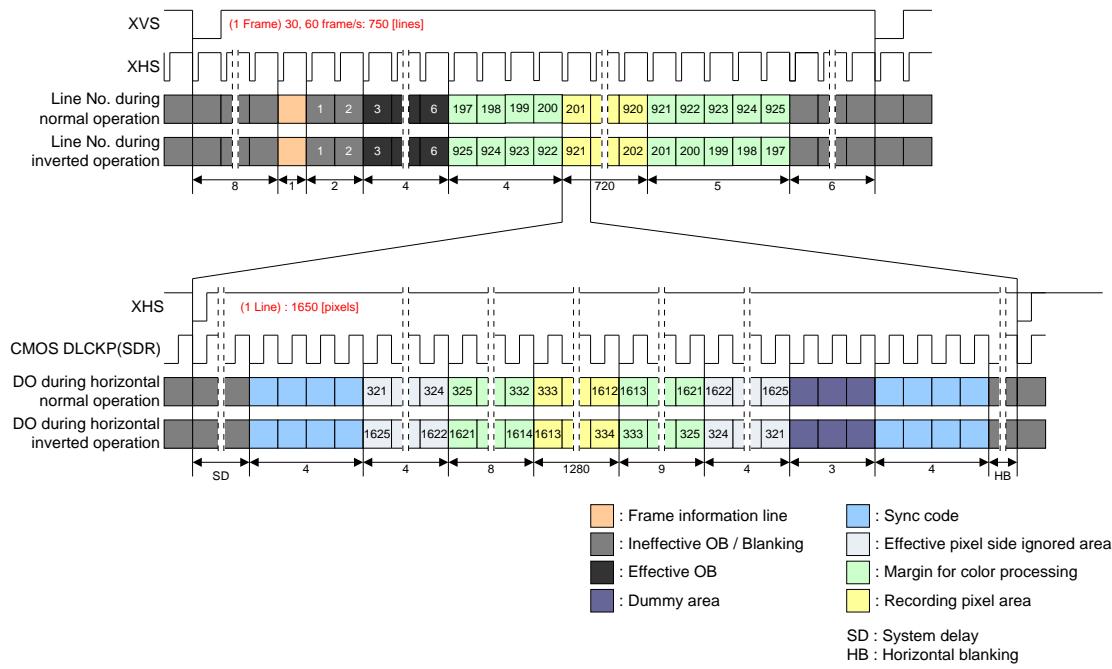
List of Setting Register for CSI-2 serial output

Address		bit	Register Name	Initial Value	CSI-2 serial					Remarks
4-wire	I ² C				2 lane		4 lane			
					30 [frame / s]	60 [frame / s]	30 [frame / s]	60 [frame / s]	120 [frame / s]	
Chip ID: 02h										
05h	3005h	[0]	ADBIT	1h			0h / 1h			0: 10 bit, 1: 12 bit
07h	3007h	[0]	VREVERSE	0h			0h / 1h			0: Normal, 1: Inverted
		[1]	HREVERSE	0h			0h / 1h			0: Normal, 1: Inverted
		[6:4]	WINMODE	0h			1h			HD 720p
09h	3009h	[1:0]	FRSEL	2h	2h	1h	2h	1h	0h	
		[4]	FDG_SEL	0h			0h / 1h			0: LCG mode, 1: HCG mode
12h	3012h	[7:0]	—	F0h			64h			Initial setting
13h	3013h	[7:0]	—	00h			00h			Initial setting
18h	3018h	[7:0]	VMAX	465h						25 / 30 / 50 / 60 / 100 / 120 [frame/s]
19h	3019h	[7:0]					2EEh			
1Ah	301Ah	[1:0]								
1Ch	301Ch	[7:0]								
1Dh	301Dh	[7:0]	HMAX	1130h	19C8h / 1EF0h	0CE4h / 0F78h	19C8h / 1EF0h	0CE4h / 0F78h	0672h / 07BCh	30 / 60 / 120 [frame / s] / 25 / 50 / 100 [frame / s]
46h	3046h	[1:0]	ODBIT	1h			1h			In CSI-2, fixed to "1h".
		[7:4]	OPORTSEL	0h			0h			In CSI-2, fixed to "0h".
5Ch	305Ch	[7:0]	INCKSEL1	0Ch			10h / 20h			
5Dh	305Dh	[7:0]	INCKSEL2	00h			00h / 00h			Set according to INCK
5Eh	305Eh	[7:0]	INCKSEL3	10h			10h / 20h			74.25/37.125 MHz
5Fh	305Fh	[7:0]	INCKSEL4	01h			01h / 01h			
Chip ID = 03h										
29h	3129h	[7:0]	ADBIT1	00h			1Dh / 00h			10bit : 1Dh 12bit : 00h
5Eh	315Eh	[7:0]	INCKSEL5	1Bh			1Bh / 1Ah			Set according to INCK 74.25 / 37.125 MHz
64h	3164h	[7:0]	INCKSEL6	1Bh			1Bh / 1Ah			Set according to INCK 74.25 / 37.125 MHz
7Ch	317Ch	[7:0]	ADBIT2	17h			12h / 00h			10bit : 12h 12bit : 00h
ECh	31ECh	[7:0]	ADBIT3	0Eh			37h / 0Eh			10bit : 37h 12bit : 0Eh
Chip ID = 04h										
00h	3200h	[7:0]	to FFh	32FFh	[7:0]	Set register value that described on item "Register map".				
00h	3300h	[7:0]				Set register value that described on item "Register map".				
Chip ID = 05h										

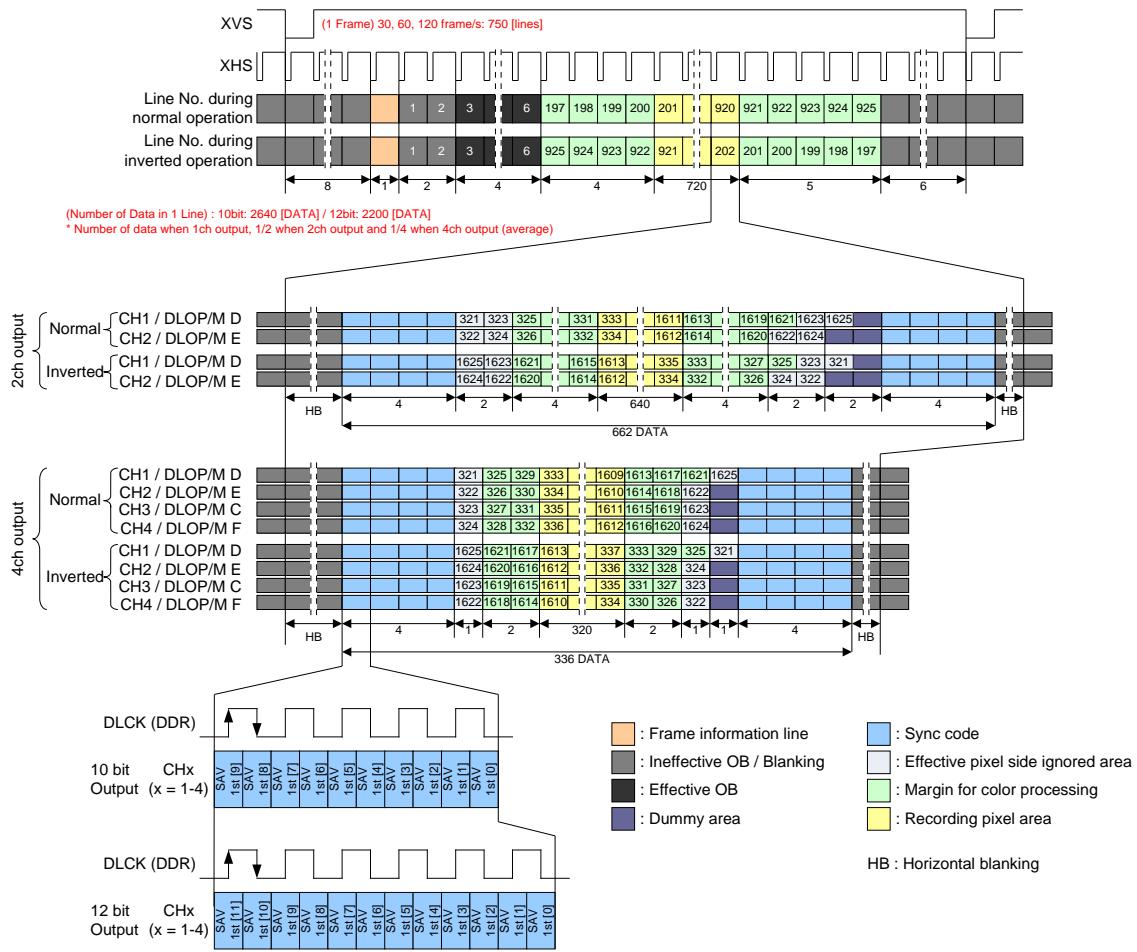
Address		bit	Register Name	Initial Value	CSI-2 serial						Remarks					
					2 lane		4 lane									
4-wire	I ² C				30 [frame /s]	60 [frame /s]	30 [frame /s]	60 [frame /s]	120 [frame /s]							
Chip ID = 06h																
				Data rate		297	594	148.5	297	594	[Mbps / Lane]					
05h	3405h	[5:4]	REPETITION	2h	1h	0h	2h	1h	0h							
07h	3407h	[1:0]	PHYSICAL_LANE_NUM	3h	1h		3h									
14h	3414h	[5:0]	OPB_SIZE_V	Ah	4h											
18h	3418h	[7:0]	Y_OUT_SIZE	0449h	2D9h											
19h	3419h	[4:0]														
41h	3441h	[7:0]	CSI_DT_FMT	0C0Ch	0A0Ah / 0C0Ch						0A0Ah: RAW10					
42h	3442h	[7:0]									0C0Ch: RAW12					
43h	3443h	[1:0]	CSI_LANE_MODE	3h	1h		3h									
44h	3444h	[7:0]	EXTCK_FREQ	4A40h	37.125 MHz: 2520h 74.25 MHz: 4A40h						Set according to INCK					
45h	3445h	[7:0]														
46h	3446h	[7:0]	TCLKPOST	047h	04Fh	067h	047h	04Fh	067h		Global timing					
47h	3447h	[0]														
48h	3448h	[7:0]	THSZERO	01Fh	02Fh	057h	017h	02Fh	057h		Global timing					
49h	3449h	[0]														
4Ah	344Ah	[7:0]	THSPREPARE	017h	017h	02Fh	00Fh	017h	02Fh		Global timing					
4Bh	344Bh	[0]														
4Ch	344Ch	[7:0]	TCLKTRAIL	00Fh	017h	027h	00Fh	017h	027h		Global timing					
4Dh	344Dh	[0]														
4Eh	344Eh	[7:0]	THSTRAIL	017h	017h	02Fh	00Fh	017h	02Fh		Global timing					
4Fh	344Fh	[0]														
50h	3450h	[7:0]	TCLKZERO	047h	057h	0BFh	02Bh	057h	0BFh		Global timing					
51h	3451h	[0]														
52h	3452h	[7:0]	TCLKPREPARE	00Fh	017h	02Fh	00Bh	017h	02Fh		Global timing					
53h	3453h	[0]														
54h	3454h	[7:0]	TLPX	00Fh	017h	027h	00Fh	017h	027h		Global timing					
55h	3455h	[0]														
72h	3472h	[7:0]	X_OUT_SIZE	079Ch	51Ch											
73h	3473h	[4:0]														



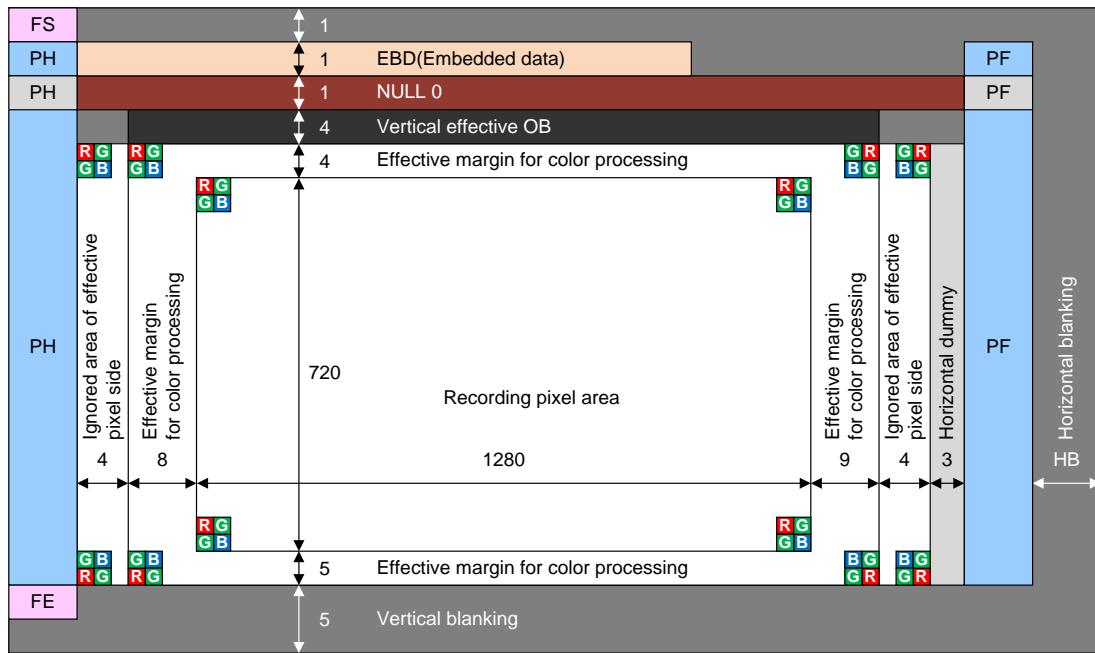
Pixel Array Image Drawing in HD720p mode (Parallel CMOS output / Serial LVDS output)



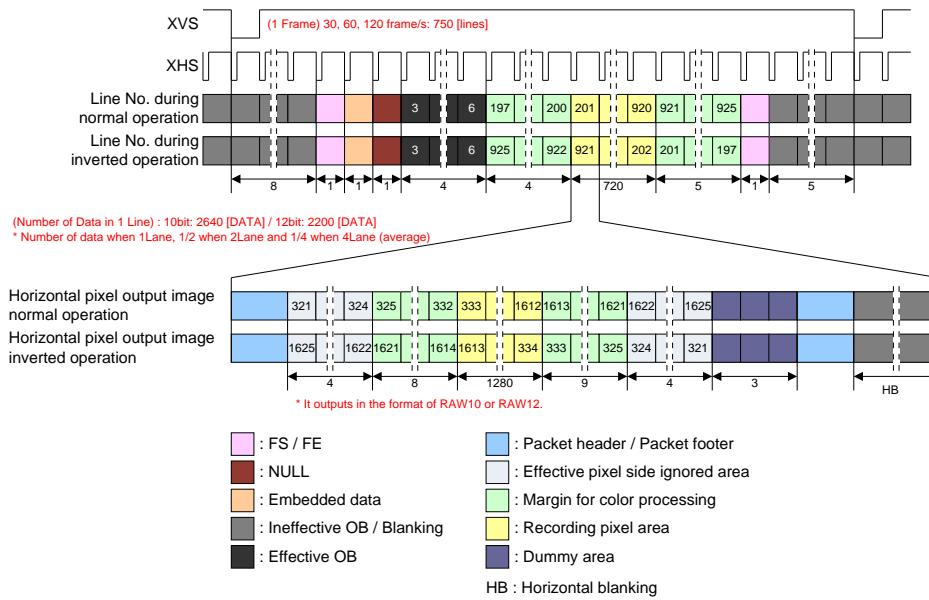
Drive Timing Chart for HD720p mode (Parallel CMOS output)



Drive Timing Chart for HD720p mode (Serial LVDS output)



Pixel Array Image Drawing in HD720p mode (CSI-2 serial output)



Drive Timing Chart for HD720p mode (CSI-2 serial output)

Description of Various Function

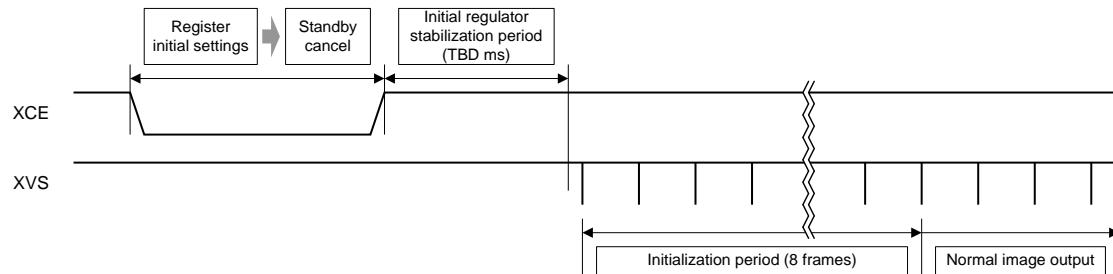
Standby Mode

This sensor stops its operation and goes into standby mode which reduces the power consumption by writing “1” to the standby control register STANDBY. Standby mode is also established after power-on or other system reset operation.

List of Standby Mode Setting

Register name	Register details				Initial value	Setting value	Status	Remarks
	Register	ChipID	Address () : I ² C	bit				
STANDBY	—	02h	00h (3000h)	[0]	1	1	Standby	Register communication is executed in standby mode.
						0	Operating	

The serial communication registers hold the previous values. However, the address registers transmitted in standby mode are overwritten. The serial communication block operates even in standby mode, so standby mode can be canceled by setting the STANDBY register to “0”. Some time is required for sensor internal circuit stabilization after standby mode is canceled. After standby mode is canceled, a normal image is output from the 9 frames after internal regulator stabilization (TBD ms or more).



Sequence from Standby Cancel to Stable Image Output

Slave Mode and Master Mode

The sensor can be switched between slave mode and master mode. The switching is made by the XMASTER pin. Establish the XMASTER pin status before canceling the system reset. (Do not switch this pin status during operation.)

Input a vertical sync signal to XVS and input a horizontal sync signal to XHS when a sensor is in slave mode. For sync signal interval, input data lines to output for vertical sync signal and 1H period designated in each operating mode for horizontal sync signal. See the section of "Operating mode" for the number of output data line and 1H period.

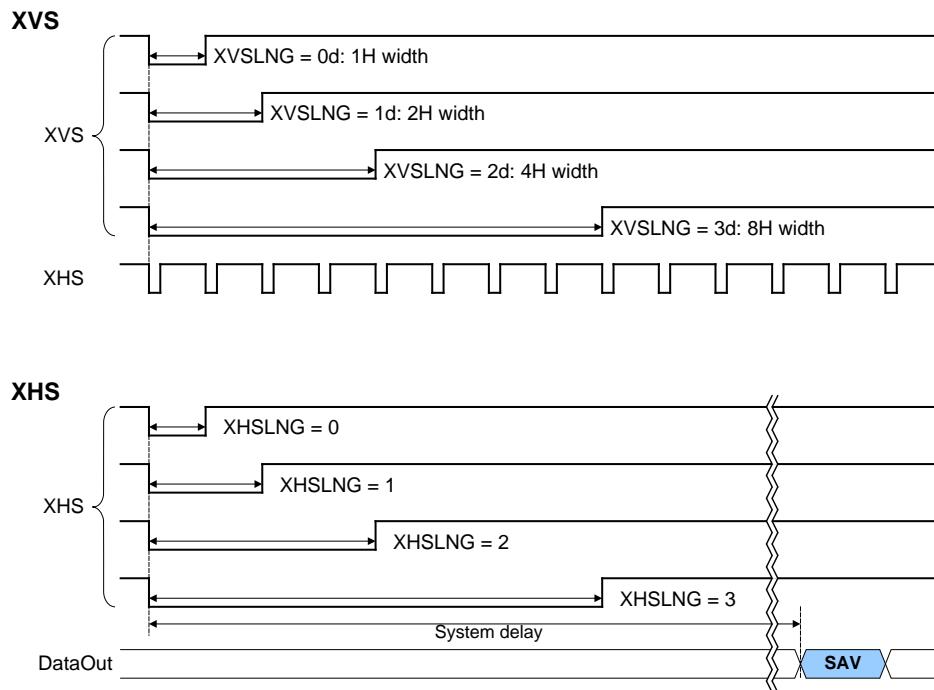
Set the XMSTA register to "0" in order to start the operation after setting to master mode. In addition, set the count number of sync signal in vertical direction by the VMAX [17:0] register and the clock number in horizontal direction by the HMAX [13:0] register. See the description of Operation Mode for details of the section of "Operating Modes".

List of Slave and Master Mode Setting

Pin name	Pin processing	Operating mode	Remarks
XMASTER pin	Fixed to Low	Master mode	High: OV _{DD} Low: GND
	Fixed to High	Slave mode	

List of Register in Master Mode

Register name	Register details (Chip ID = 02h)			Initial value	Setting value	Remarks
	Register	Address () : I ² C	bit			
XMSTA	—	02h (3002h)	[0]	1	1: Master operation ready 0: Master operation start	The master operation starts by setting 0.
VMAX [17:0]	VMAX [7:0]	18h (3018h)	[7:0]	00465h	See the item of each drive mode.	Line number per frame designated
	VMAX [15:8]	19h (3019h)	[7:0]			
	VMAX [17:16]	1Ah (301Ah)	[1:0]			
HMAX [13:0]	HMAX [7:0]	1Ch (301Ch)	[7:0]	1130h	See the item of each drive mode.	Clock number per line designated
	HMAX [15:8]	1Dh (301Dh)	[7:0]			
XVSLNG [1:0]	—	48h (3048h)	[5:4]	0h	0: 1H, 1: 2H, 2: 4H, 3: 8H	XVS low level pulse width designated
XHSLNG [1:0]	—	49h (3049h)	[5:4]	0h	0: Min. to 3: Max. See the next	XHS low level pulse width designated
XVSOUTSEL [1:0]	—	4Bh (304Bh)	[1:0]	0h	0: Fixed to High 2: VSYNC output Others: Setting prohibited	
XHSOUTSEL [1:0]	—		[3:2]	0h	0: Fixed to High 2: HSYNC output Others: Setting prohibited	



XVS/XHS output waveform in sensor master mode

List of XHSLNG Register

	CMOS parallel output		LVDS serial output					
DCK	74.25 [MHz]	37.125 [MHz]	594 [Mbps / ch]	297 [Mbps / ch]	148.5 [Mbps / ch]	445.5 [Mbps / ch]	222.75 [Mbps / ch]	111.375 [Mbps / ch]
XHSLNG = 0	8 clk	4 clk	64 bit	32 bit	16 bit	48 bit	24 bit	12 bit
XHSLNG = 1	16 clk	8 clk	128 bit	64 bit	32 bit	96 bit	48 bit	24 bit
XHSLNG = 2	32 clk	16 clk	256 bit	128 bit	64 bit	192 bit	96 bit	48 bit
XHSLNG = 3	64 clk	32 clk	512 bit	256 bit	128 bit	384 bit	192 bit	96 bit

The XVS and XHS are output in timing that set 0 to the register XMSTA. If set 0 to XMSTA during standby, the XVS and XHS are output just after standby is released. The XVS and XHS are output asynchronous with other input or output signals. In addition, the output signals are output with an undefined latency time (system delay) relative to the XHS. Therefore, refer to the sync codes output from the sensor and perform synchronization.

Gain Adjustment Function

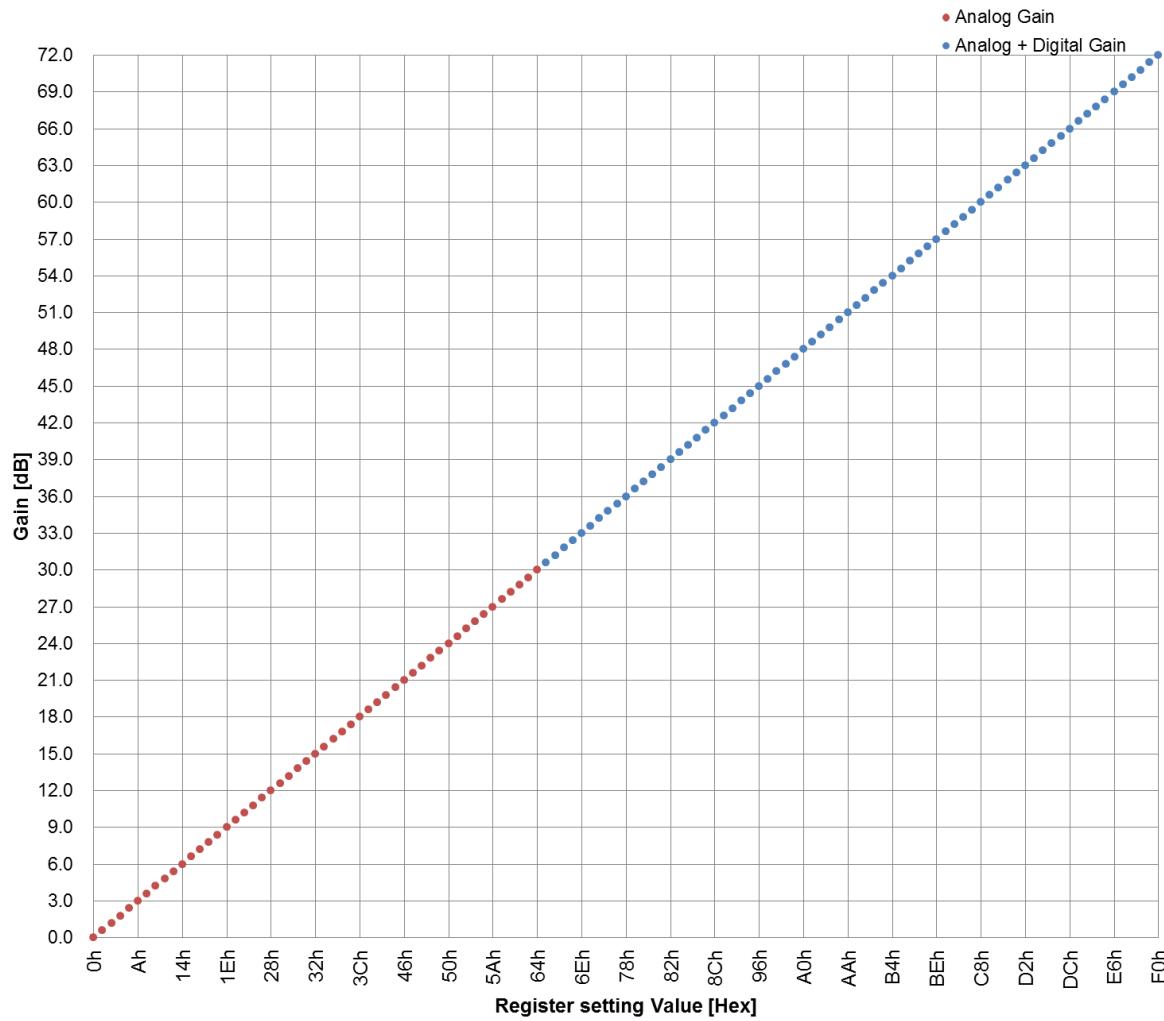
The Programmable Gain Control (PGC) of this device consists of the analog block and digital block. The total of analog gain and digital gain can be set up to 72 dB by the GAIN [7:0] register setting. The same setting is applied in all colors.

The value which is 10/3 times the gain is set to register. (0.3 dB step)

Example)

When set to 6 dB: $6 \times 10/3 = 20d$; GAIN [7:0] = 14h

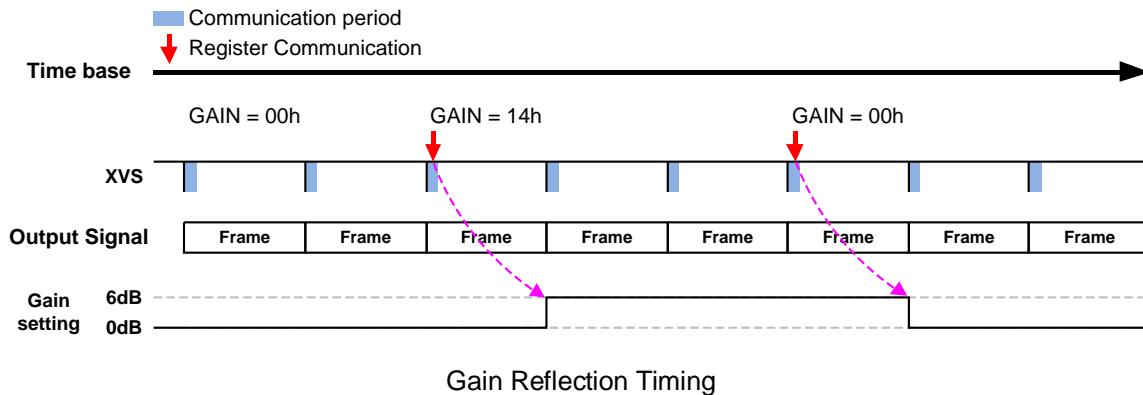
When set to 12.6 dB: $12.6 \times 10/3 = 42d$; GAIN [7:0] = 2Ah



List of PGC Register

Register name	Register details (Chip ID = 02h)			Initial value	Setting value	Remarks
	Register	Address () : I ² C	bit		Setting range	
GAIN [7:0]	GAIN [7:0]	14h (3014h)	[7:0]	00h	00h-F0h (0d-240d)	Setting value: Gain [dB] × 10/3 (0.3 dB step)

The gain setting is reflected at the next frame that the communication is performed as shown below.



Black Level Adjustment Function

The black level offset (offset variable range: 000h to 1FFh) can be added relative to the data in which the digital gain modulation was performed by the BLKLEVEL [8:0] register. When the BLKLEVEL setting is increased by 1 LSB, the black level is increased by 1 LSB.

Use with values shown below is recommended.

10-bit output: 03Ch (60d)

12-bit output: 0F0h (240d)

List of Black Level Adjustment Register

Register name	Register details (Chip ID = 02h)			Initial value	Setting value
	Register	Address () : I ² C	bit		
BLKLEVEL [8:0]	BLKLEVEL [7:0]	0Ah (300Ah)	[7:0]	0F0h	000h to 1FFh
	BLKLEVEL [8]	0Bh (300Bh)	[0]		

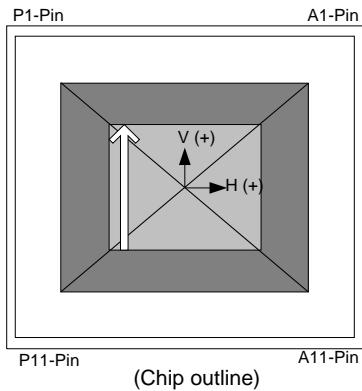
Normal Operation and Inverted Operation

The sensor readout direction (normal / inverted) in vertical direction can be switched by the VREVERSE register setting and in horizontal direction can be switched by the HREVERSE register setting. See the section of “Operating Modes” for the order of readout lines in normal and inverted modes. One invalid frame is generated when reading immediately after the readout direction change in order to switch the normal operation and inversion between frames.

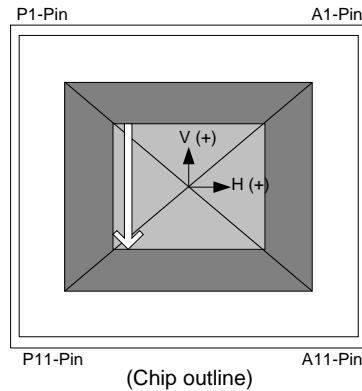
List of Drive Direction Setting Register

Register name	Register details (Chip ID = 02h)			Initial value	Setting value
	Register	Address () : I ² C	bit		
VREVERSE	—	07h (3007h)	[0]	0h	0: Normal (Initial value) 1: Vertical Inverted
HREVERSE	—		[1]	0h	0: Normal (Initial value) 1: Horizontal Inverted

In normal mode

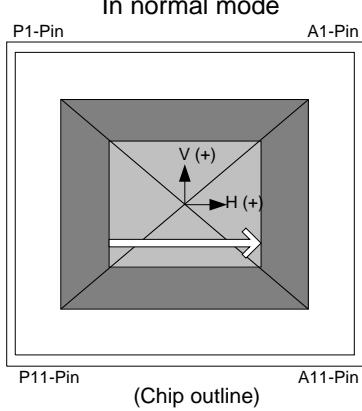


In inverted mode

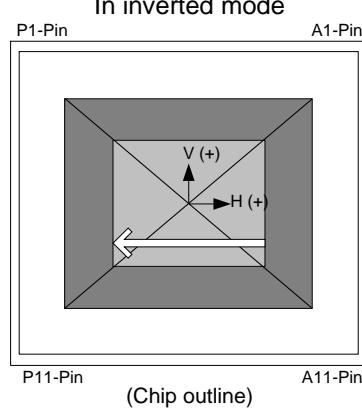


Normal and Inverted Drive Outline in Vertical Direction (TOP VIEW)

In normal mode



In inverted mode



Normal and Inverted Drive Outline in Horizontal Direction (TOP VIEW)

Shutter and Integration Time Settings

This sensor has a variable electronic shutter function that can control the integration time in line units. In addition, this sensor performs rolling shutter operation in which electronic shutter and readout operation are performed sequentially for each line.

Note) For integration time control, an image which reflects the setting is output from the frame after the setting changes.

Example of Integration Time Setting

The sensor's integration time is obtained by the following formula.

$$\text{Intefration time} = 1 \text{ frame period} - (\text{SHS1} + 1) \times (1\text{H period})$$

*1 The frame period is determined by the input XVS when the sensor is operating in slave mode, or the register VMAX value in master mode. The frame period is designated in 1H units, so the time is determined by (Number of lines \times 1H period).

*2 See "Operating Modes" for the 1H period.

In this section, the shutter operation and storage time are shown as in the figure below with the time sequence on the horizontal axis and the vertical address on the vertical axis. For simplification, shutter and readout operation are noted in line units.

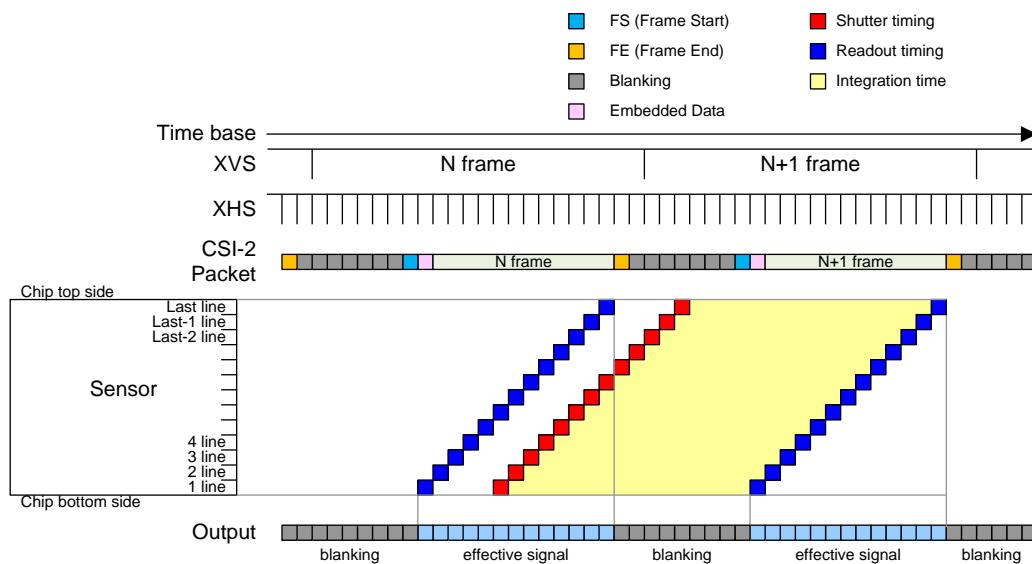


Image Drawing of Shutter Operation

Normal Exposure Operation (Controlling the Integration Time in 1H Units)

The integration time can be controlled by varying the electronic shutter timing. In the electronic shutter settings, the integration time is controlled by the SHS1 [17:0] register. Set SHS1 [17:0] to a value between 1 and (Number of lines per frame - 1). When the sensor is operating in slave mode, the number of lines per frame is determined by the XVS interval (number of lines), using the input XHS interval as the line unit.

When the sensor is operating in master mode, the number of lines per frame is determined by the VMAX register. The number of lines per frame differs according to the operating mode.

Registers Used to Set the Integration Time in 1H Units

Register name	Register details (Chip ID = 02h)			Initial value	Setting value
	Register	Address (): I ² C	bit		
SHS1 [17:0]	SHS1 [7:0]	20h (3020h)	[7:0]	00000h	Sets the shutter sweep time. 1 to (Number of lines per frame - 2) * 0 and number of lines per frame -1 setting is prohibited
	SHS1 [15:8]	21h (3021h)	[7:0]		
	SHS1 [17:16]	22h (3022h)	[1:0]		
VMAX [17:0]	VMAX [7:0]	18h (3018h)	[7:0]	00465h	Sets the number of lines per frame (only in master mode). See "Operating Modes" for the setting value in each mode.
	VMAX [15:8]	19h (3019h)	[7:0]		
	VMAX [17:16]	1Ah (301Ah)	[1:0]		

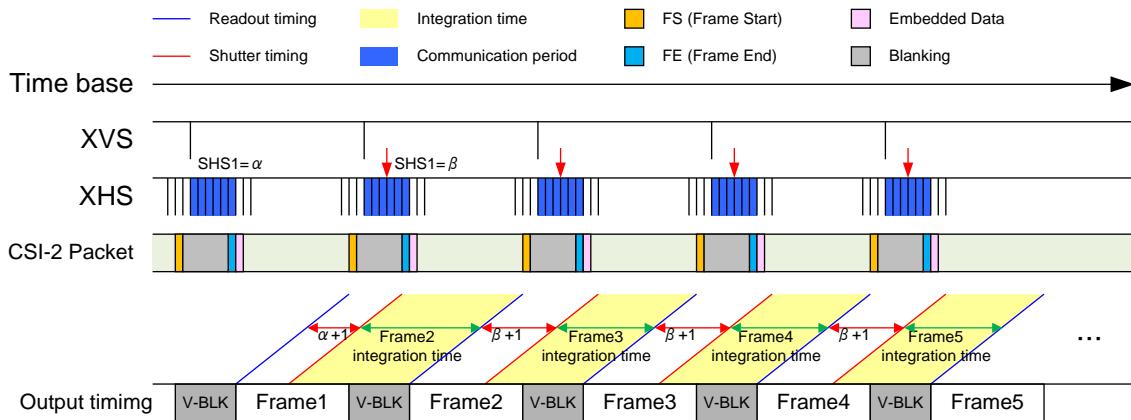


Image Drawing of Integration Time Control within a Frame

Long Exposure Operation (Control by Expanding the Number of Lines per Frame)

Long exposure operation can be performed by lengthening the frame period.

When the sensor is operating in slave mode, this is done by lengthening the input vertical sync signal (XVS) pulse interval.

When the sensor is operating in master mode, it is done by designating a larger register VMAX [17:0] value compared to normal operation. When the integration time is extended by increasing the number of lines, the rear V blanking increases by an equivalent amount.

Although the maximum value of long exposure operation changes in each modes, the maximum of long time exposure is approximately 1 s.

When set to a number of V lines or more than that noted for each operating mode, the imaging characteristics are not guaranteed during long exposure operation.

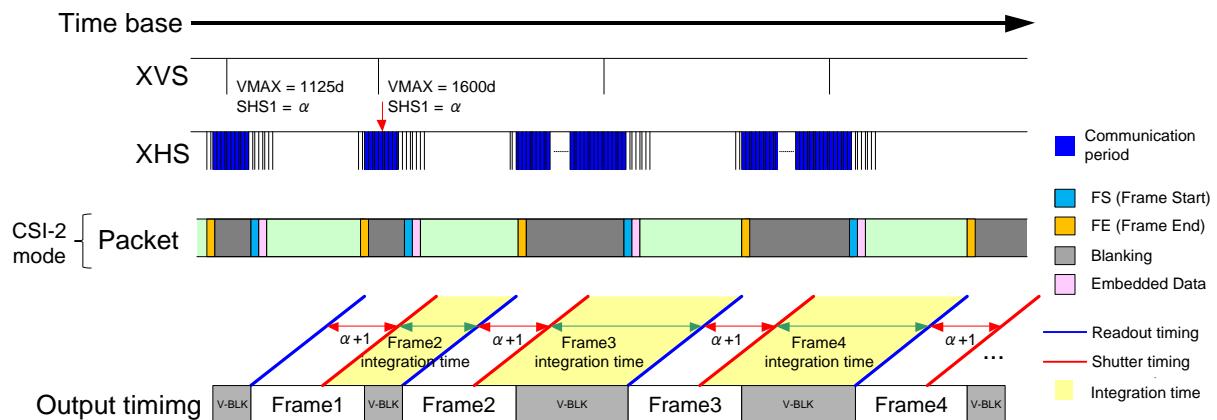


Image Drawing of Long Integration Time Control by Adjusting the Frame Period

Example of Integration Time Settings

The example of register setting for controlling the storage time is shown below.

Example of Integration Time Settings (In Full HD 1080p)

Operation	Sensor setting (register)		Integration time
	VMAX*	SHS1**	
Normal frame rate	1125	1123	1H
		:	:
		N	(1125 - (N + 1)) H
		:	:
		1	1123H

* In sensor master mode. In slave mode, the interval is the same as XVS input.

** The SHS1 setting value (N) is set between "1" and "the VMAX value (M) – 2".

Signal Output

Output Pin Settings

The output formats of this sensor support the following modes.

CMOS logic parallel SDR output

Low voltage LVDS serial (2 ch / 4 ch / 8 ch switching) DDR output

CSI-2 serial (2 Lane / 4 Lane, RAW10 / RAW12) output

The switching for serial interface is made by the OMODE pin. Establish the OMODE pin status before canceling the system reset. (Do not switch this pin status during operation.) Each mode is set using the register OPORTSEL. The table below shows the output format settings.

List of Interface Switching

Pin name	Pin	Interface	Remarks
OMODE pin	Fixed to Low	CSI-2 serial	High: OVDD Low: GND
	Fixed to High	CMOS parallel SDR Low voltage LVDS serial	

List of Output Interface Setting Register

Register name	Register details (Chip ID = 02h)		Initial value	Setting value	Description
	Address () : I ² C	bit			
OPORTSEL [3:0]	46h (3046h)	[7:4]	0h	0h	CMOS logic parallel SDR output
				Dh	Low voltage LVDS serial 2 ch DDR
				Eh	Low voltage LVDS serial 4 ch DDR
				Fh	Low voltage LVDS serial 8 ch DDR
				N/A	CSI-2 serial 2Lane
				N/A	CSI-2 serial 4Lane

* In CMOS output, Clock is output from DLCKP pin. DLCKM pin is fixed to low level.

* In CSI-2 output, set registers that described in section “CSI-2 output setting”.

Each output pin is shown in the table below when setting low-voltage LVDS serial 2 ch / 4 ch / 8 ch output.

Output Pins for Low LVDS Serial and CMOS parallel

DLOP/DLOM	CMOS logic parallel SDR output		Low voltage LVDS serial DDR output		
	10 bit	12 bit	2 ch	4 ch	8 ch
DLOMH	Low fixed	Low fixed	Hi-Z	Hi-Z	Ch8 / M
DLOPH	Low fixed	Low fixed	Hi-Z	Hi-Z	Ch8 / P
DLOMG	DO9	DO11	Hi-Z	Hi-Z	Ch6 / M
DLOPG	DO8	DO10	Hi-Z	Hi-Z	Ch6 / P
DLOMF	DO7	DO9	Hi-Z	Ch4 / M	Ch4 / M
DLOPF	DO6	DO8	Hi-Z	Ch4 / P	Ch4 / P
DLOME	DO5	DO7	Ch2 / M	Ch2 / M	Ch2 / M
DLOPE	DO4	DO6	Ch2 / P	Ch2 / P	Ch2 / P
DLOMD	DO3	DO5	Ch1 / M	Ch1 / M	Ch1 / M
DLOPD	DO2	DO4	Ch1 / P	Ch1 / P	Ch1 / P
DLOMC	DO1	DO3	Hi-Z	Ch3 / M	Ch3 / M
DLOPC	DO0	DO2	Hi-Z	Ch3 / P	Ch3 / P
DLOMB	Low fixed	DO1	Hi-Z	Hi-Z	Ch5 / M
DLOPB	Low fixed	DO0	Hi-Z	Hi-Z	Ch5 / P
DLOMA	Low fixed	Low fixed	Hi-Z	Hi-Z	Ch7 / M
DLOPA	Low fixed	Low fixed	Hi-Z	Hi-Z	Ch7 / P

Low-voltage LVDS serial 2 ch / 4 ch / 8 ch output format is shown in the figure below.

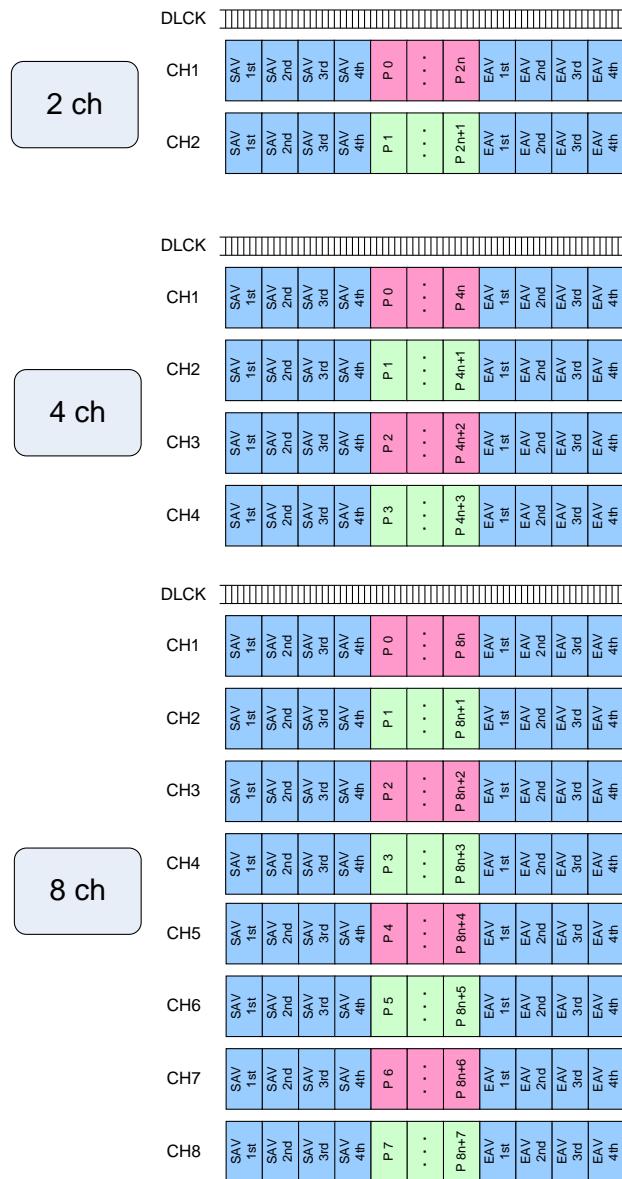
When setting 2 ch, after four data of SAV is output in the order of CH1 and CH2 pixel data is repeatedly output in the same order and then four data of EAV is output in the same order to CH1 and CH2 respectively.

When setting 4 ch, after four data of SAV is output in the order of CH1, CH2, CH3 and CH4 pixel data is repeatedly output in the same order and then four data of EAV is output in the same order to CH1, CH2, CH3 and CH4 respectively.

When setting 8 ch, after four data of SAV is output in the order of CH1, CH2, CH3, CH4, CH5, CH6, CH7 and CH8 pixel data is repeatedly output in the same order and then four data of EAV is output in the same order to CH1, CH2, CH3, CH4, CH5, CH6, CH7 and CH8 respectively.

Data is sent MSB first.

For details, see drive timing in each mode in the section of "Operation Mode".



Output Format of Low voltage LVDS Serial 2 ch / 4 ch / 8 ch

CSI-2 output

The output formats of this sensor support the following modes.

CSI-2 serial 2 Lane / 4 Lane, RAW10 / RAW12

The 2 Lane / 4 Lane serial signal output method using this sensor is described below.

Complied with the CSI-2, data is output using 2 Lane / 4 Lane. The image data is output from the CSI-2 output pin. The DMO1P/DMO1N are called the Lane1 data signal, the DMO2P/DMO2N are called the Lane2 data signal, the DMO3P/DMO3N are called the Lane3 data signal, the DMO4P/DMO4N are called the Lane4 data signal. In addition, the clock signals are output from DMCKP/DMCKN of the CSI-2 pins.

In 2 Lane mode, data is output from Lane1 and Lane2. In 4 Lane mode, data is output from Lane1, Lane2, Lane3 and Lane4. The bit rate maximum value is 891 Mbps / Lane.

The select of RAW10 / RAW12 is set by the register: CSI_DT_FMT [15:0] The number of output lanes is set by the register: CSI_LANE_MODE [1:0] and the number of lanes physically connected is set by PHYSICAL_LANE_NUM [1:0]. Unused lanes (when setting 2 lanes; DMO3P / DMO3N, DMO4P / DMO4N) are set to Hi-Z output by the setting. When the number of lanes more than CSI_LANE_MODE is set by PHYSICAL_LANE_NUM, unused lanes output signals conformed to MIPI standard.

Register name	Register details (Chip ID = 06h)		Initial value	Setting value	Description
	Address () : I ² C	bit			
CSI_DT_FMT [15:0]	41h (3441h)	[7:0]	0C0Ch	0A0Ah	RAW10
	42h (3442h)	[7:0]		0C0Ch	RAW12
PHYSICAL_LANE_NUM [1:0]	07h (3407h)	[1:0]	3h	0h	Setting prohibited
				1h	2Lane
				2h	Setting prohibited
				3h	4Lane
CSI_LANE_MODE [1:0]	43h (3443h)	[1:0]	3h	0h	Setting prohibited
				1h	2Lane
				2h	Setting prohibited
				3h	4Lane

The formats of RAW12 and RAW10 are shown below.



→ RAW12 Format

P0 [4] P0 [5] P0 [6] P0 [7] P0 [8] P0 [9] P0 [10] P0 [11] P1 [4] P1 [5] P1 [6] P1 [7] P1 [8] P1 [9] P1 [10] P1 [11] P0 [0] P0 [1] P0 [2] P0 [3] P1 [0] P1 [1] P1 [2] P1 [3] P2 [4] P2 [5] P2 [6] P2 [7] P2 [8] P2 [9] P2 [10] P2 [11] P3 [4] P3 [5] P3 [6] P3 [7] P3 [8] P3 [9] P3 [10] P3 [11] ...

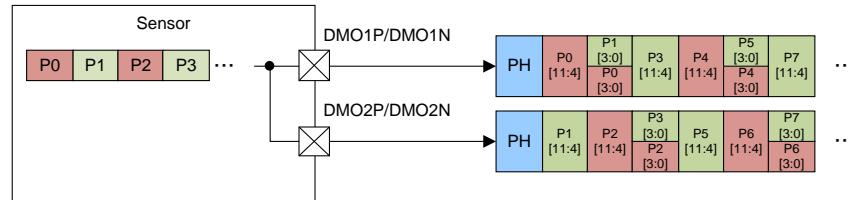
→ RAW10 Format

P0 [2] P0 [3] P0 [4] P0 [5] P0 [6] P0 [7] P0 [8] P0 [9] P1 [2] P1 [3] P1 [4] P1 [5] P1 [6] P1 [7] P1 [8] P1 [9] P2 [2] P2 [3] P2 [4] P2 [5] P2 [6] P2 [7] P2 [8] P2 [9] P3 [2] P3 [3] P3 [4] P3 [5] P3 [6] P3 [7] P3 [8] P3 [9] P0 [0] P0 [1] P1 [0] P1 [1] P2 [0] P2 [1] P3 [0] P3 [1] ...

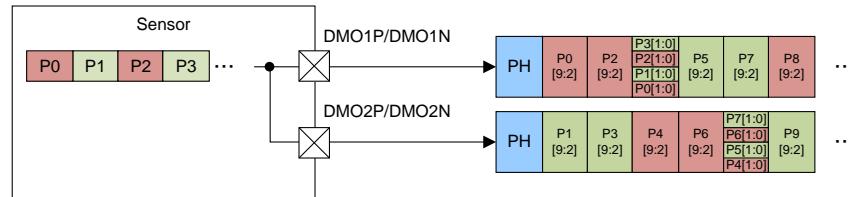
The Example of Format of RAW12 / RAW10

The each formal of 2 Lane and 4 Lane are shown below.

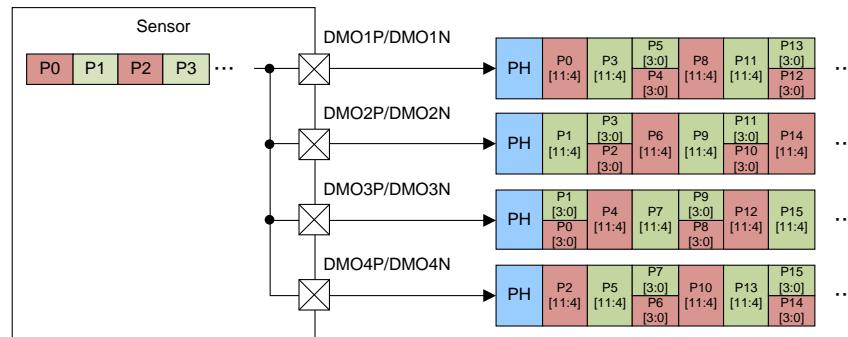
a) 2 Lane-Raw12



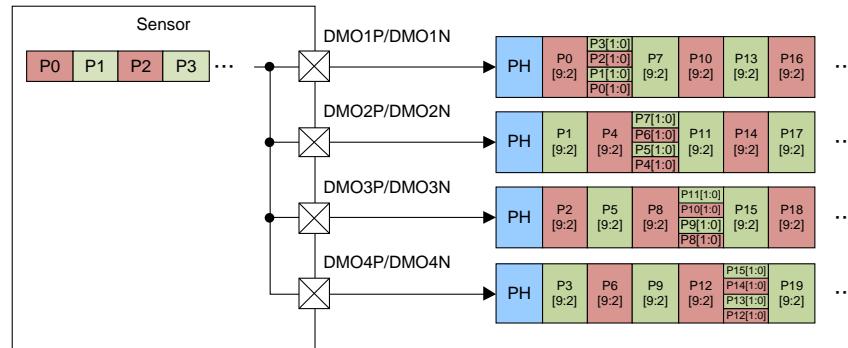
b) 2 Lane-Raw10



c) 4 Lane-Raw12



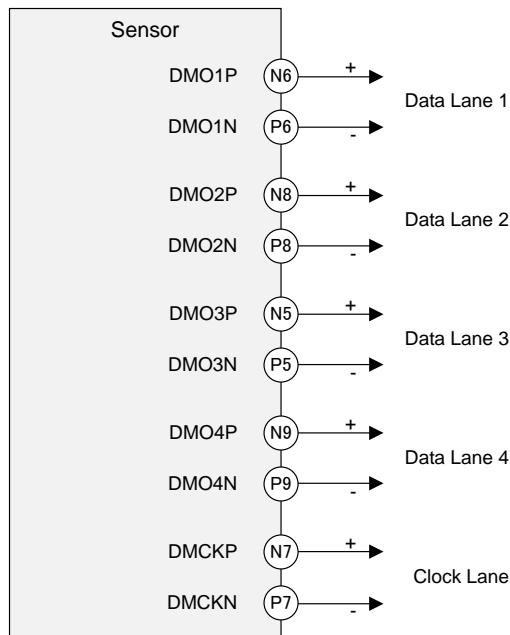
d) 2 Lane-Raw10



2 Lane / 4 Lane Output Format

MIPI Transmitter

Output pins (DMO1P, DMO1N, DMO2P, DMO2N, DMO3P, DMO3N, DMO4P, DMO4D, DMCKP, DMCKN) are described in this section.



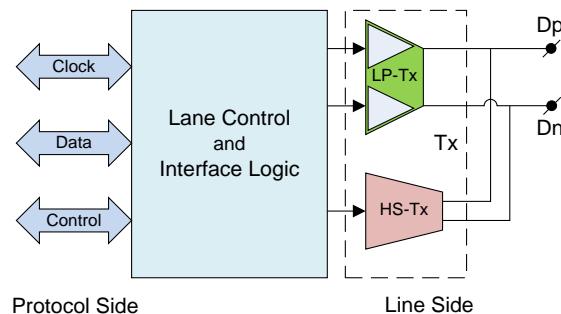
Relationship between Pin Name and MIPI Output Lane

The pixel signals are output by the CSI-2 High-speed serial interface.

See the MIPI Standard

- MIPI Alliance Standard for Camera Serial Interface 2 (CSI-2) Version 1.01.00
- MIPI Alliance Specification for D-PHY Version 1.00.00

The CSI-2 transfers one bit with a pair of differential signals. The transmitter outputs differential current signal after converting pixel signals to it. Insert external resistance in differential pair in a series or use cells with a built-in resistance on the Receiver side. When inserting an external resistor, as close as possible to the Receiver. The differential signals maintain a constant interval and reach the receiver with the shortest wiring length possible to avoid malfunction. The maximum bit rate of each Lane are 891 Mbps / Lane.



Universal Lane Module Functions

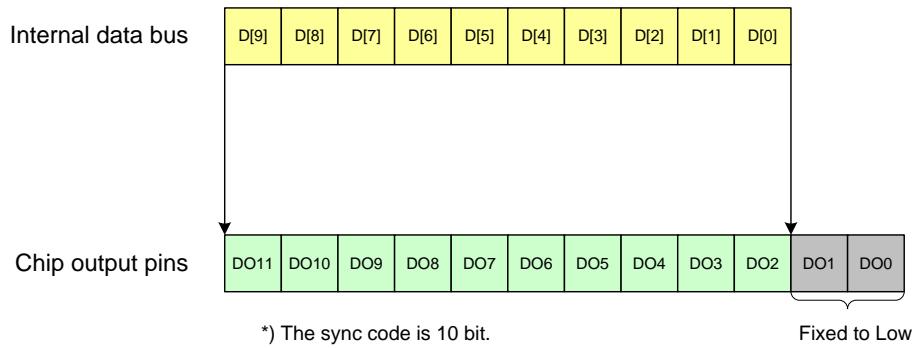
Output Pin Bit Width Selection

The output pin width can be selected from 10-bit or 12-bit output using the register ODBIT. In parallel output mode, when ODBIT = 0 (10-bit output), the lower 2 bits are fixed to Low level in CMOS output mode. Therefore, when using only 10 bits, the pins corresponding to the lower 2 bits can be left open on the board by setting ODBIT = 0. When low-voltage LVDS serial output, continuous data is output MSB first by 10-bit and 12-bit output setting respectively. 10-bits sync code are output when ODBIT = 0 (10-bit output), and 12-bit sync codes are output when ODBIT = 1 (12-bit output).

Output Pin Bit Width Selection Setting Register

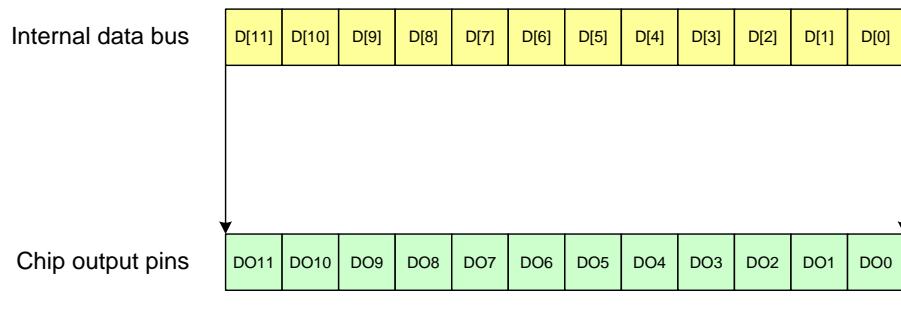
Register name	Register details (Chip ID = 02h)			Initial value	Setting value
	Register	Address () : I ² C	bit		
ODBIT	—	46h (3046h)	[0]	0h	0: 10 bit 1: 12 bit

ODBIT = 0 (CMOS Parallel 10 bit output)



Bit Assignments in Parallel 10-bit Output Mode

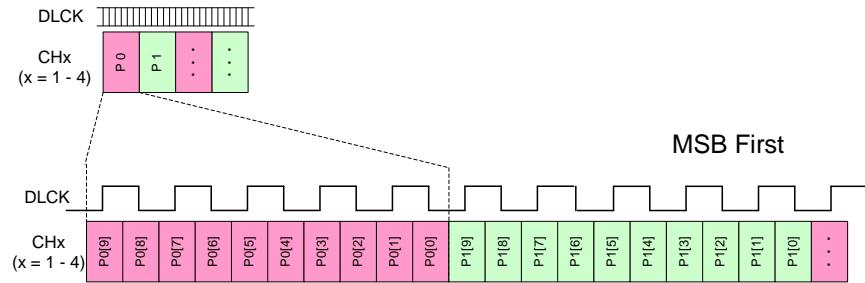
ODBIT = 1 (CMOS Parallel 12 bit output)



*) The sync code is 12 bit.

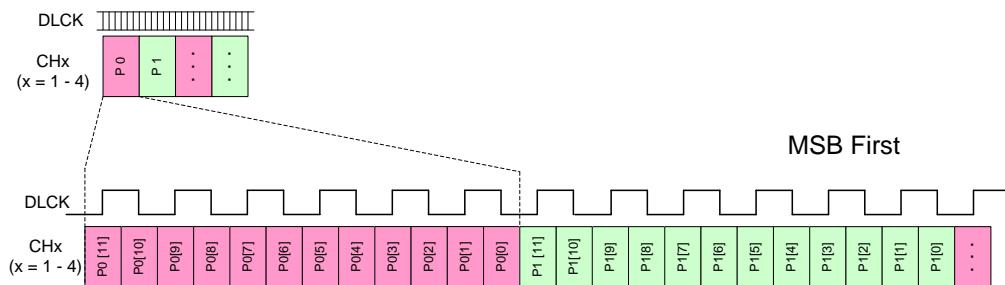
Bit Assignments in Parallel 12-bit Output Mode

ODBIT = 0 (Low voltage LVDS serial 10 bit output)



Example of Data format in low-voltage LVDS serial 10-bit output

ODBIT = 1 (Low voltage LVDS serial 12 bit output)



Example of Data format in low-voltage LVDS serial 12-bit output

Number of Internal A/D Conversion Bits Setting

The number of internal A/D conversion bits can be selected from 10 bits or 12 bits by the register ADBIT. See the section of "Operating Modes" for the correspondence with each mode.

List of Bit Width Selection

Register name	Register details *1 : Chip ID = 02h *2 : Chip ID = 03h			Initial value	Setting value
	Register	Address () : I ² C	bit		
ADBIT	—	05h (3005h)	[0]	1h	0: 10 bit 1: 12 bit
ADBIT1[7:0]	—	29h *2 (3129h)	[7:0]	00h	10bit : 1Dh 12bit : 00h
ADBIT2[7:0]	—	7Ch *2 (317Ch)	[7:0]	17h	10bit : 12h 12bit : 00h
ADBIT3[7:0]	—	29h *2 (31ECh)	[7:0]	0Eh	10bit : 37h 12bit : 0Eh

Output Rate Setting

The sensor output rate is determined uniformly by the sensor operating mode and the output format. See the section of “Operating Modes” for the relationship between each setting and the frame rate, data rate and data bit rate. The registers related to mode setting are shown in the table below.

Related Registers for Setting Operation Mode

Register name	Register details (Chip ID = 02h)			Initial value	Setting value
	Register	Address () : I ² C	bit		
WINMODE [2:0]	—	07h (3007h)	[6:4]	0h	0: Full HD 1080p 1: 720 p 4: Window cropping from Full HD 1080p
FRSEL [1:0]	—	09h (3009h)	[1:0]	1h	0: 120 frame / s 1: 60 frame / s 2: 30 frame / s 3: Setting prohibited

Output Signal Range

In sub LVDS output and CMOS parallel output mode, the sensor output has 10 bit or 12 bit gray scale according to the setting. The output is not performed at full range and the range is the values shown in the table below. See the item of “Sync Codes” in the section of “Operating Modes” for the sync codes.

Output Gradation and Output Range (Low voltage LVDS Output)

Output gradation	Output value	
	Min.	Max.
10 bit	001h	3FEh
12 bit	001h	FFEh

In CSI-2 output mode, the sensor output has either a 10 bit or 12 bit gradation, but output is not performed over the full range, and the maximum output value is the 3FFh value (10 bit output) and the FFFh one (12 bit output).

The output range for each output gradation is shown in the table below.

Output Gradation and Output Range (CSI-2 Output)

Output gradation	Output value	
	Min.	Max.
10 bit	000h	3FFh
12 bit	000h	FFFh

INCK Setting

The available operation mode varies according to INCK frequency. Input either 37.125 MHz or 74.25 MHz for INCK frequency. The INCK setting register and the list of INCK setting are shown in the table below.

INCK Setting Register

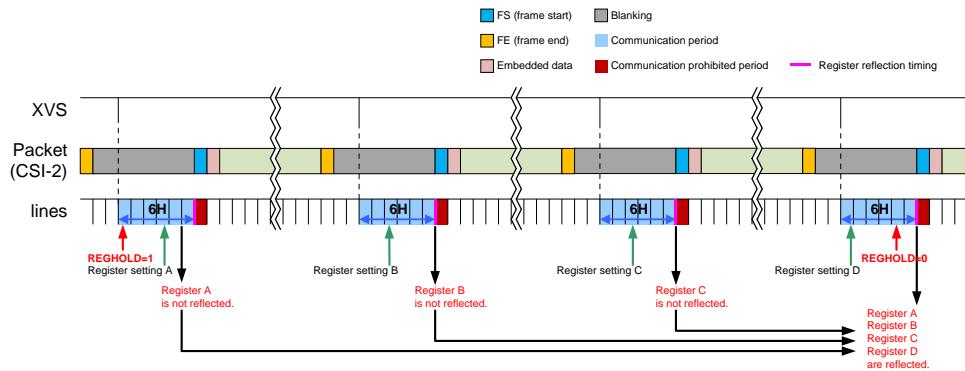
Register name	Register details *1 : Chip ID = 02h *2 : Chip ID = 03h			Initial value	INCK = 37.125 MHz			INCK = 74.25 MHz		
	Register	Address () : I ² C	bit		1080p CMOS LVDS	1080p CSI-2	720p	1080p CMOS LVDS	1080p CSI-2	720p
INCKSEL1	—	5Ch *1 (305Ch)	[7:0]	0Ch	18h	18h	20h	0Ch	0Ch	10h
INCKSEL2	—	5Dh *1 (305Dh)	[7:0]	00h	00h	03h	00h	00h	03h	00h
INCKSEL3	—	5Eh *1 (305Eh)	[7:0]	10h	20h	20h	20h	10h	10h	10h
INCKSEL4	—	5Fh *1 (305Fh)	[7:0]	01h	01h	01h	01h	01h	01h	01h
INCKSEL5	—	5Eh *2 (315Eh)	[7:0]	1Bh	1Ah	1Ah	1Ah	1Bh	1Bh	1Bh
INCKSEL6	—	64h *2 (3164h)	[7:0]	1Bh	1Ah	1Ah	1Ah	1Bh	1Bh	1Bh

Register Hold Setting

Register setting can be transmitted with divided to several frames and it can be reflected globally at a certain frame by the register REGHOLD. Setting REGHOLD = 1 at the start of register communication period prevents the registers that are set thereafter from reflecting at the frame reflection timing. The registers that are set when setting REGHOLD = 1 are reflected globally by setting REGHOLD = 0 at the end of communication period of the desired frame to reflect the register.

Register Hold Setting Register

Register name	Register details (Chip ID = 02h)			Initial value	Setting value	
	Register	Address () : I ² C	bit			
REGHOLD	—	01h (3001h)	[0]	0h	0: Invalid	1: Valid (Register hold)



Register Hold Setting

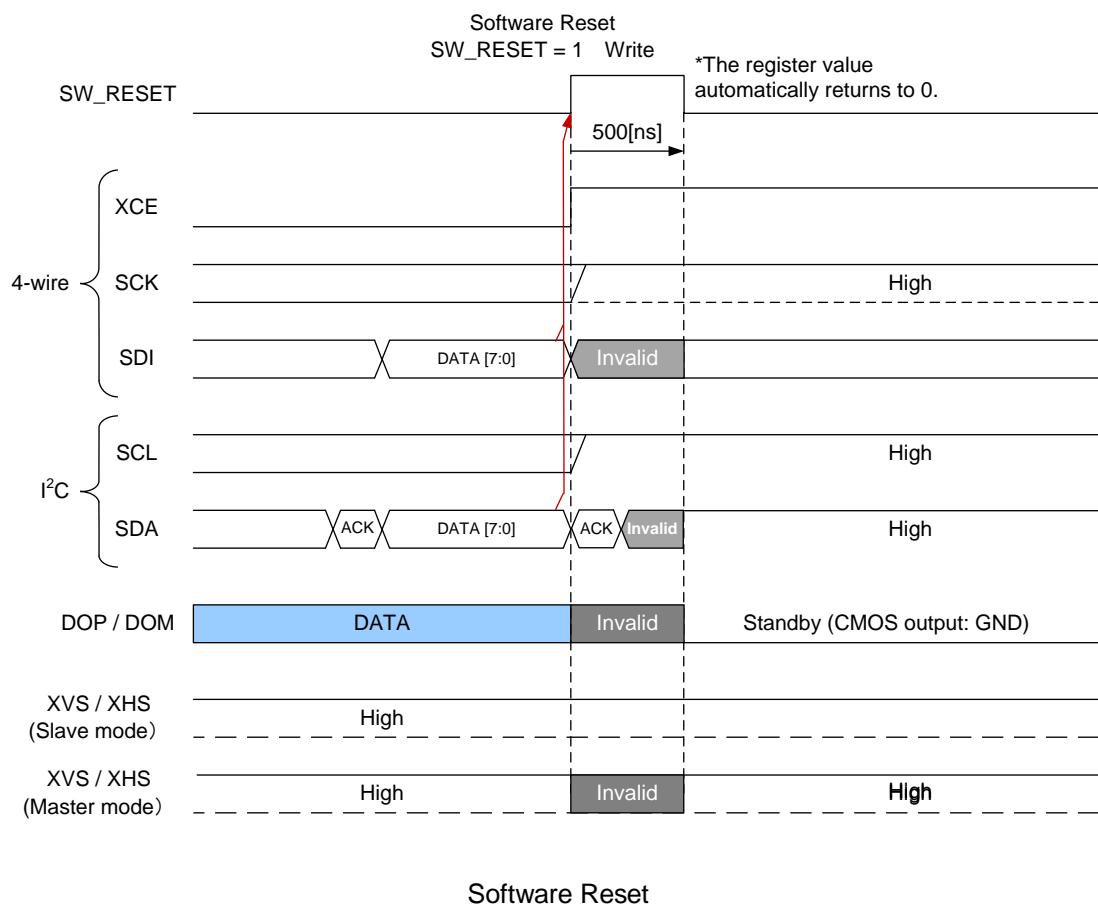
Software Reset (CMOS parallel / Low voltage LVDS serial only)

This function is prohibited in CSI-2 output mode.

Software reset can be performed by register setting using the register SW_RESET. Sensor reset is performed by setting SW_RESET = 1. However, the communication to continuous address cannot use. The registers become initial state and standby 500 ns after setting SW_RESET = 1. The SW_RESET signal returns to "0" automatically. The DOPA-H/DOMA-H/DCKP/DCKM terminal will be in the standby state (GND) of the CMOS output. The XVS and XHS output High in master mode. Input High to the XVS and XHS before setting SW_RESET = 1 in slave mode. Follow the sequence in the item of "Standby Mode" to perform register initial setting and standby cancel from standby state.

Software Reset Register Setting

Register name	Register details (Chip ID = 02h)			Initial value	Setting value
	Register	Address () : I ² C	bit		
SW_RESET	—	03h (3003h)	[0]	0h	0: Normal Operation 1: Reset



Mode Transitions

When changing the operating mode during sensor drive operation, set via sensor standby. However, these transitions that described below can be transitions without standby.

- ◆ Change the number of vertical lines (In sensor master mode, change the VMAX. In sensor slave mode, change the period of XVS input.)
- ◆ Horizontal and vertical scan direction. (When the vertical scan direction is changed, an invalid frame generates during transition.)
- ◆ Change the HCG mode and LCG mode.
- ◆ Change the mode between All-pixel scan and Window cropping. (However, It is case that transitions by not changing register HMAX and FRSEL. In addition, an invalid frame generates during transition.)

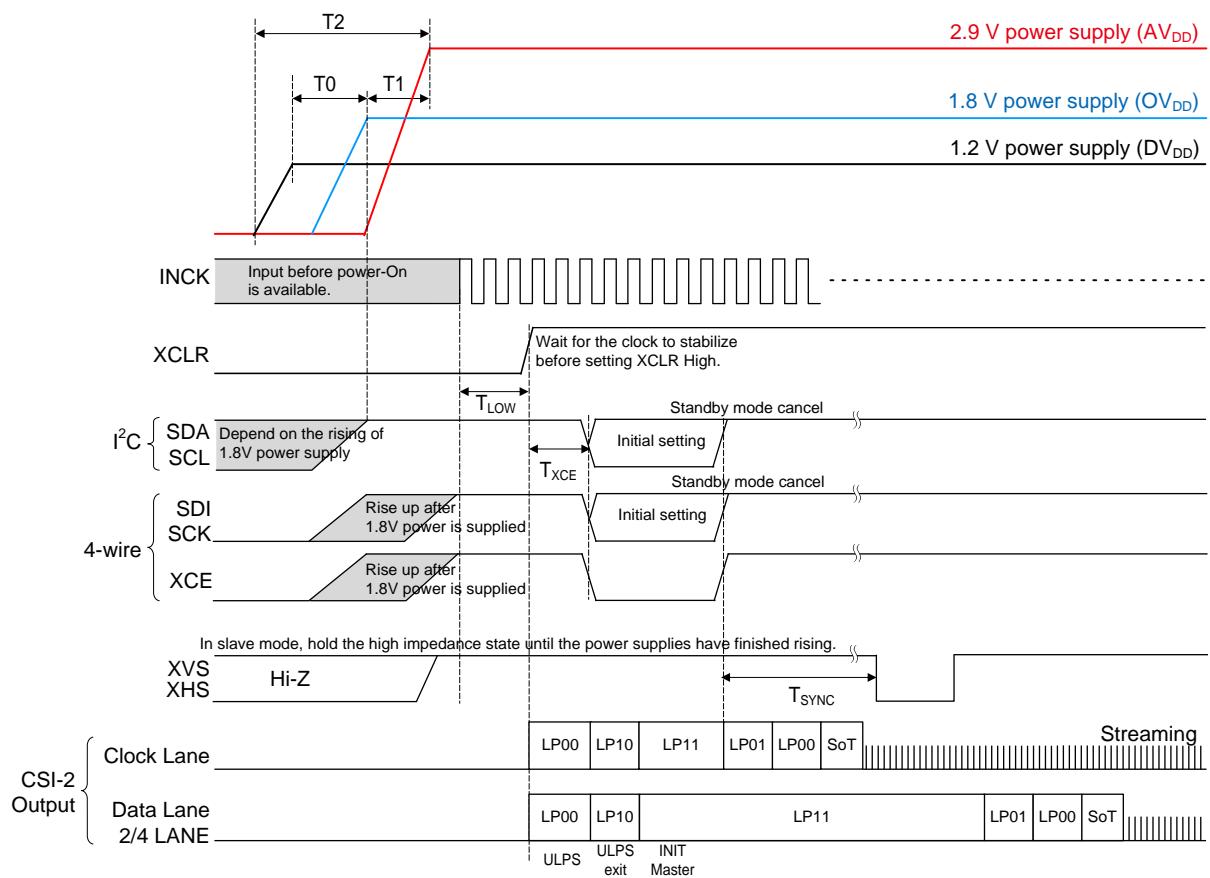
When changing input INCK frequency (register INCKSEL1, INCKSEL2, INCKSEL3, INCKSEL4, INCKSEL5, and INCKSEL6 change) or when operating mode transition that changes output bit width (register ODBIT) or output format (register OPORTSEL [3:0]), always start the operation via sensor standby after changing mode during standby following the standby cancel sequence.

When changing input INCK frequency, care should be taken not to be input pulses whose width are shorter than the High / Low level width in front and behind of the INCK pulse at the frequency change. If the pulses above generate at the frequency change, change INCK frequency during system reset in the state of XCLR = Low, and then perform system clear in the state of XCLR = High following the item of "Power on sequence" in the section of "Power on / off sequence". Execute initial setting again because the register settings become default state after system clear.

Power-on and Power-off Sequence

Power-on sequence

1. Turn On the power supplies so that the power supplies rise in order of 1.2 V power supply (DV_{DD}) → 1.8 V power supply (OV_{DD}) → 2.9 V power supply (AV_{DD}). In addition, all power supplies should finish rising within 200 ms.
2. Start master clock (INCK) input after turning On the power supplies.
3. The register values are undefined immediately after power-on, so the system must be cleared. Hold XCLR at Low level for 500 ns or more after all the power supplies have finished rising. (The register values after a system clear are the default values.) In addition, hold XCE to High level during this period. Rise XCE after 1.8 V power supply (OV_{DD}).
4. The system clear is applied by setting XCLR to High level. However, the master clock needs to stabilize before setting the XCLR pin to High level.
5. Make the sensor setting by register communication after the system clear. A period of 20 μs or more should be provided after setting XCLR High before inputting the communication enable signal XCE. In I²C communication, XCE is fixed to High.

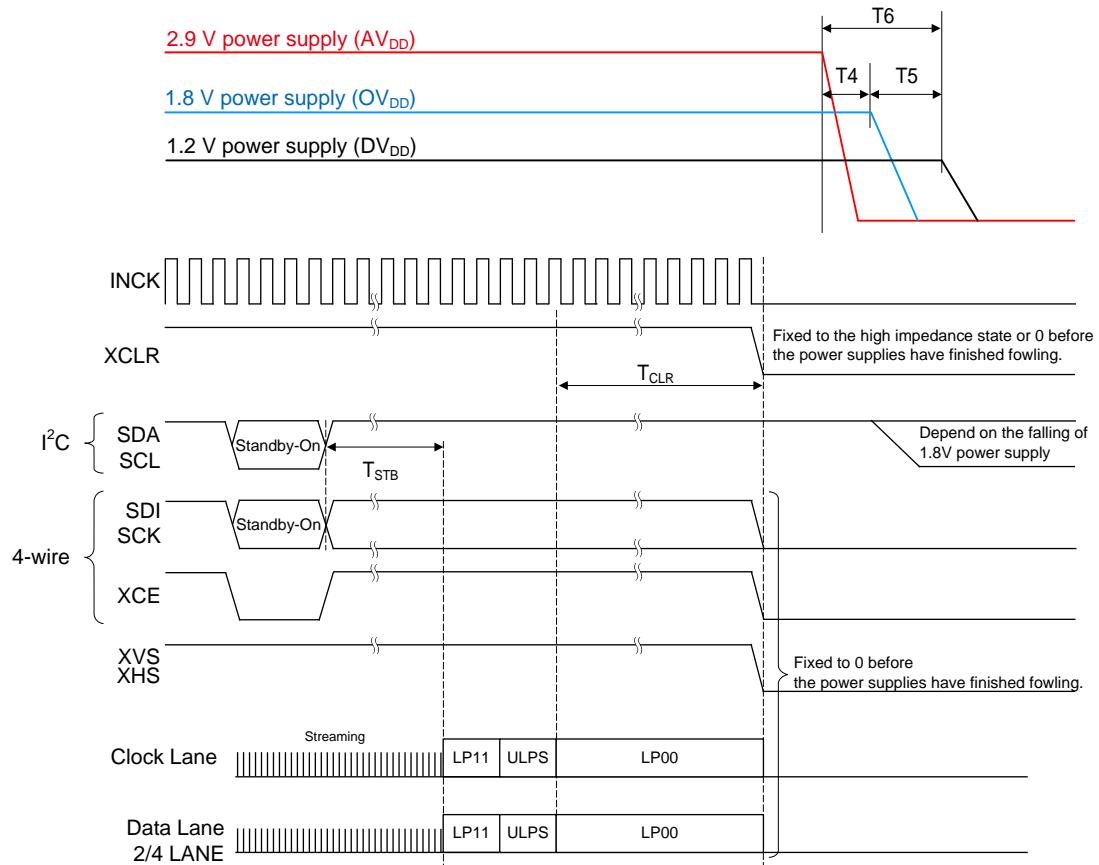


Power-on Sequence

Item	Symbol	Min.	Max.	Unit
1.2 V power supply rising → 1.8 V power supply rising	T_0	0	—	ns
1.8 V power supply rising → 2.9 V power supply rising	T_1	0	—	ns
Rising time of all power supply	T_2	—	200	ms
INCK active → Clear OFF	T_{LOW}	500	—	ns
Clear OFF → Communication start	T_{XCE}	20	—	μs
Standby OFF (communication) → External input XHS,XVS (slave mode only)	T_{SYNC}	20	—	ms

Power-off sequence

Turn Off the power supplies so that the power supplies fall in order of 2.9 V power supply (AV_{DD}) → 1.8 V power supply (OV_{DD}) → 1.2 V power supply (DV_{DD}). In addition, all power supplies should falling within 200 ms. Set each digital input pin (INCK, XCE, SCK, SDI, XCLR, XMMASTER, OMODE, XVS, XHS) to 0 V before the 1.8 V power supply (OV_{DD}) falls.



Power-off Sequence

Item	Symbol	Min.	Max.	Unit
Standby ON (communication) → LP11 mode start	T_{STB}		Until FE	—
LP00 → XCLR falling	T_{CLR}	128	—	cycle
2.9 V power shut down → 1.8 V power shut down	T_4	0	—	ns
1.8 V power shut down → 1.2 V power shut down	T_5	0	—	ns
Shut down time of all power supply	T_6	—	200	ms

Sensor Setting Flow

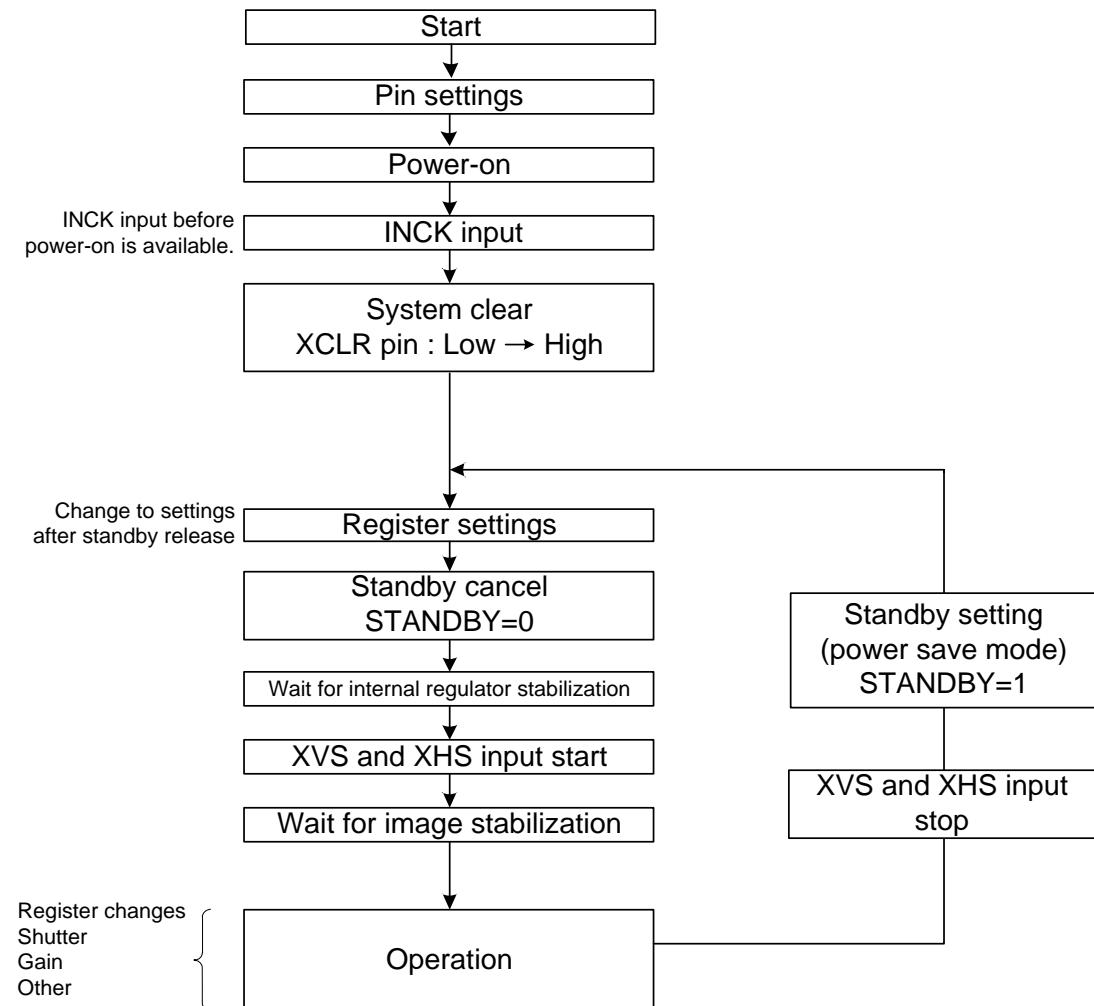
Setting Flow in Sensor Slave Mode

The figure below shows operating flow in sensor slave mode.

For details of "Power-on" to "Reset cancel", see the item of "Power-on sequence" in this section.

For details of "Standby cancel" until "Wait for image stabilization", see the item of "Standby mode".

"Standby setting (power save mode) can be made by setting the STANDBY register to "1" during "Operation".



Sensor Setting Flow (Sensor Slave Mode)

Setting Flow in Sensor Master Mode

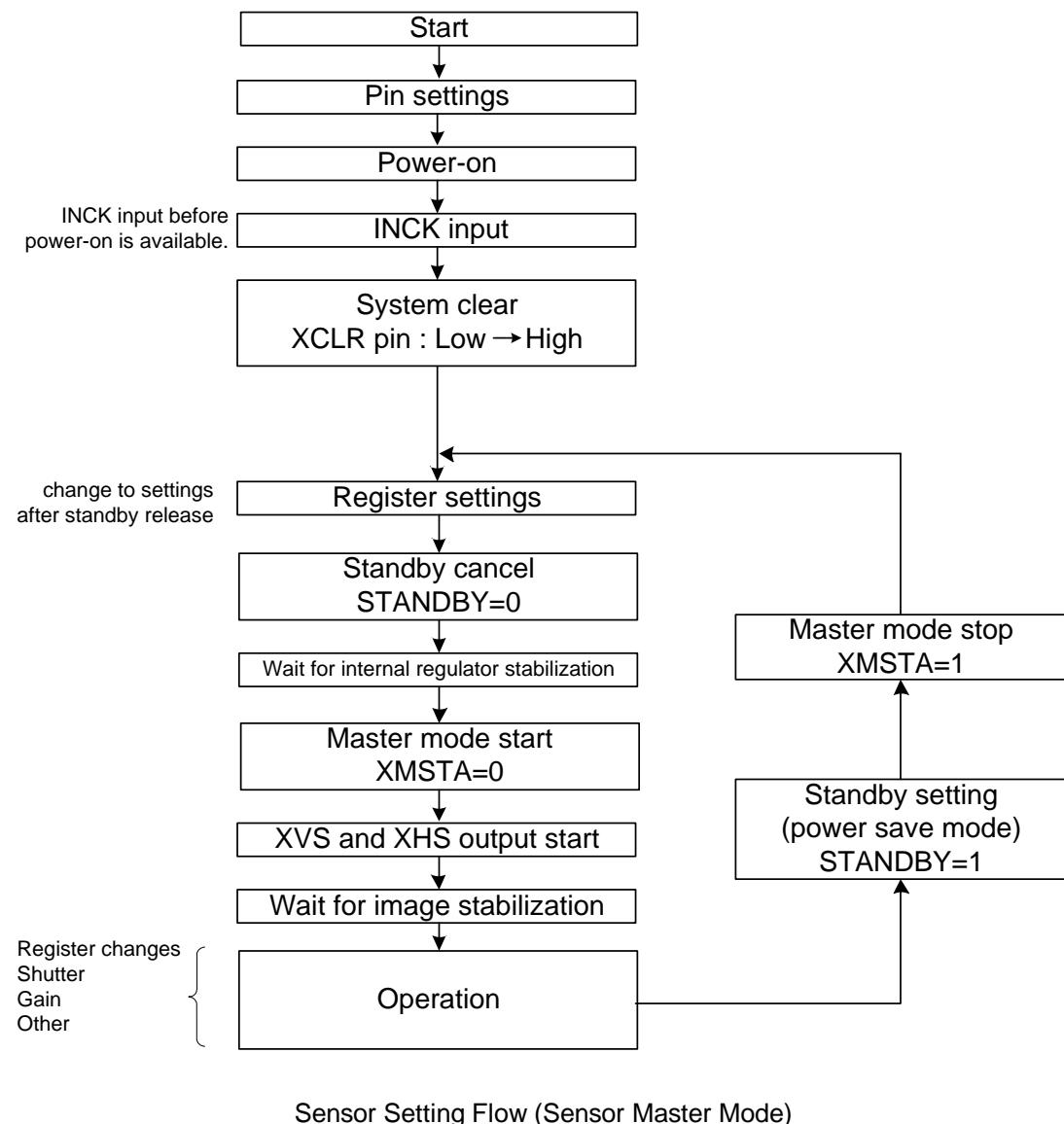
The figure below shows operating flow in sensor master mode.

For details of "Power-on" to "Reset cancel", see the item of "Power on sequence" in this section.

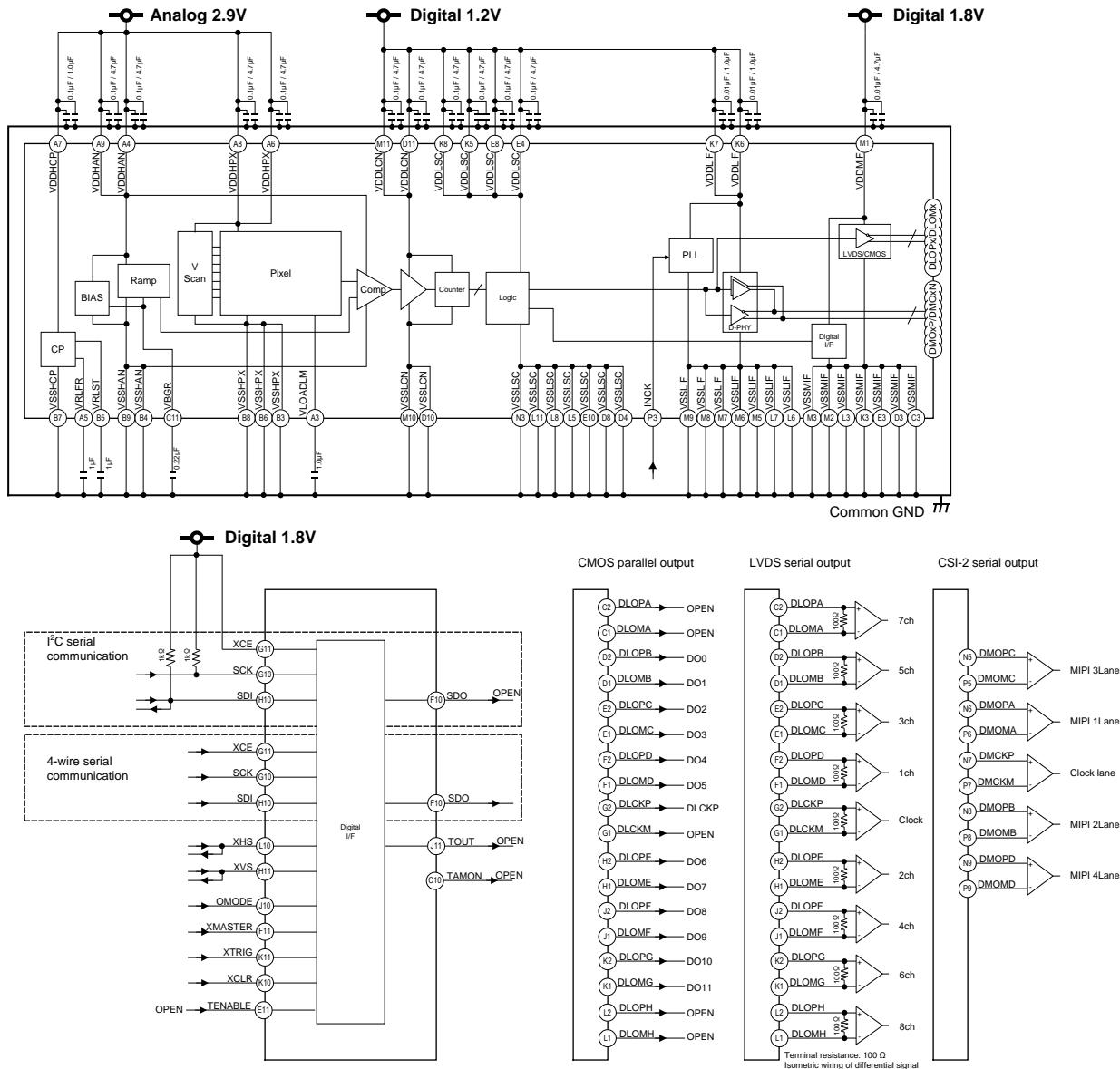
For details of "Standby cancel" until "Wait for image stabilization", see the item of "Standby mode".

In master mode, "Master mode start" by setting register XMSTA to "0" after "Waiting for internal regulator stabilization"

"Standby setting (power save mode) can be made by setting the STANDBY register to "1" during "Operation". This time, set "master mode stop" by setting XMSTA to "1".



Peripheral Circuit



Application circuits shown are typical examples illustrating the operation of the devices.
Sony cannot assume responsibility for any problems arising out of the use of these circuits or for any infringement of third party and other right due to same.

Spot Pixel Specifications

(AV_{DD} = 2.9 V, OV_{DD} = 1.8 V, DV_{DD} = 1.2 V, T_j = 60 °C, 30 frame/s, Gain: 0 dB)

Type of distortion	Level	Maximum distorted pixels in each zone				Measurement method	Remarks
		0 to II'	Effective OB	III	Ineffective OB		
Black or white pixels at high light	30 % ≤ D	15	No evaluation criteria applied				1
White pixels in the dark	5.6 mV ≤ D	150		No evaluation criteria applied		2	1/30 s storage
Black pixels at signal saturated	D ≤ 730 mV	0	No evaluation criteria applied				3

- Note) 1. Zone is specified based on all-pixel drive mode
 2. D Spot pixel level
 3. See the Spot Pixel Pattern Specifications for the specifications in which pixel and black pixel are close.

Zone Definition

TBD

Notice on White Pixels Specifications

After delivery inspection of CMOS image sensors, cosmic radiation may distort pixels of CMOS image sensors, and then distorted pixels may cause white point effects in dark signals in picture images. (Such white point effects shall be hereinafter referred to as "White Pixels".) Unfortunately, it is not possible with current scientific technology for CMOS image sensors to prevent such White Pixels. It is recommended that when you use CMOS image sensors, you should consider taking measures against such White Pixels, such as adoption of automatic compensation systems for White Pixels in dark signals and establishment of quality assurance standards.

Unless the Seller's liability for White Pixels is otherwise set forth in an agreement between you and the Seller, Sony Corporation or its distributors (hereinafter collectively referred to as the "Seller") will, at the Seller's expense, replace such CMOS image sensors, in the event the CMOS image sensors delivered by the Seller are found to be to the Seller's satisfaction, to have over the allowable range of White Pixels as set forth as set forth above under the heading "Spot Pixels Specifications", within the period of three months after the delivery date of such CMOS image sensors from the Seller to you; provided that the Seller disclaims and will not assume any liability after if you have incorporated such CMOS image sensors into other products.

Please be aware that Seller disclaims and will not assume any liability for (1) CMOS image sensors fabricated, altered or modified after delivery to you, (2) CMOS image sensors incorporated into other products, (3) CMOS image sensors shipped to a third party in any form whatsoever, or (4) CMOS image sensors delivered to you over three months ago. Except the above mentioned replacement by Seller, neither Sony Corporation nor its distributors will assume any liability for White Pixels. Please resolve any problem or trouble arising from or in connection with White Pixels at your costs and expenses.

[For Your Reference] The Annual Number of White Pixels Occurrence

The chart below shows the predictable data on the annual number of White Pixels occurrence in a single-story building in Tokyo at an altitude of 0 meters. It is recommended that you should consider taking measures against the annual White Pixels, such as adoption of automatic compensation systems appropriate for each annual number of White Pixels occurrence.

The data in the chart is based on records of past field tests, and signifies estimated number of White Pixels calculated according to structures and electrical properties of each device. Moreover, the data in the chart is for your reference purpose only, and is not to be used as part of any CMOS image sensor specifications.

Example of Annual Number of Occurrence

White Pixel Level (in case of integration time = 1/30 s) (T _j = 60 °C)	Annual number of occurrence
5.6 mV or higher	TBD pcs
10.0 mV or higher	TBD pcs
24.0 mV or higher	TBD pcs
50.0 mV or higher	TBD pcs
72.0 mV or higher	TBD pcs

- Note 1) The above data indicates the number of White Pixels occurrence when a CMOS image sensor is left for a year.
- Note 2) The annual number of White Pixels occurrence fluctuates depending on the CMOS image sensor storage environment (such as altitude, geomagnetic latitude and building structure), time (solar activity effects) and so on. Moreover, there may be statistic errors. Please take notice and understand that this is an example of test data with experiments that have been conducted over a specific time period and in a specific environment.
- Note 3) This data does not guarantee the upper limits of the number of White Pixels occurrence.

For Your Reference:

The annual number of White Pixels occurrence at an altitude of 3,000 meters is from 5 to 10 times more than that at an altitude of 0 meters because of the density of the cosmic rays. In addition, in high latitude geographical areas such as London and New York, the density of cosmic rays increases due to a difference in the geomagnetic density, so the annual number of White Pixels occurrence in such areas approximately doubles when compared with that in Tokyo.

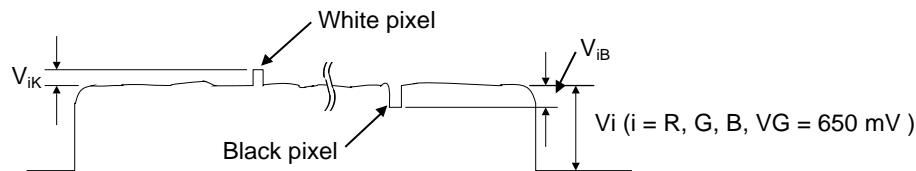
Measurement Method for Spot Pixels

After setting to standard imaging condition II, and the device driver should be set to meet bias and clock voltage conditions. Configure the drive circuit according to the example and measure.

1. Black or white pixels at high light

After adjusting the luminous intensity so that the average value V_G of the Gb / Gr signal outputs is 650 mV, measure the local dip point (black pixel at high light, V_{iB}) and peak point (white pixel at high light, V_{ik}) in the Gr / Gb / R / B signal output V_i ($i = Gr / Gb / R / B$), and substitute the value into the following formula.

$$\text{Spot pixel level } D = ((V_{ik} \text{ or } V_{iB}) / \text{Average value of } V_i) \times 100 [\%]$$



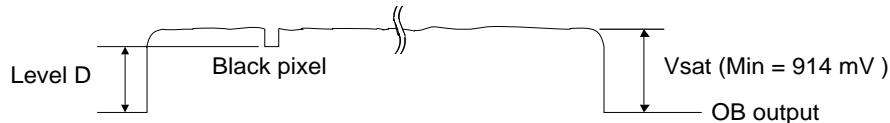
Signal output waveform of R / G / B channel

2. White pixels in the dark

Set the device to a dark setting and measure the local peak point of the signal output waveform, using the average value of the dark signal output as a reference.

3. Black pixels at signal saturated

Set the device to operate in saturation and measure the local dip point, using the OB output as a reference.

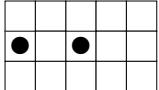
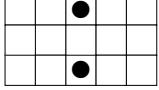


Signal output waveform of R/G/B channel

Spot Pixel Pattern Specification

White Pixel, Black Pixel and Bright Pixel are judged from the pattern whether they are allowed or rejected, and counted.

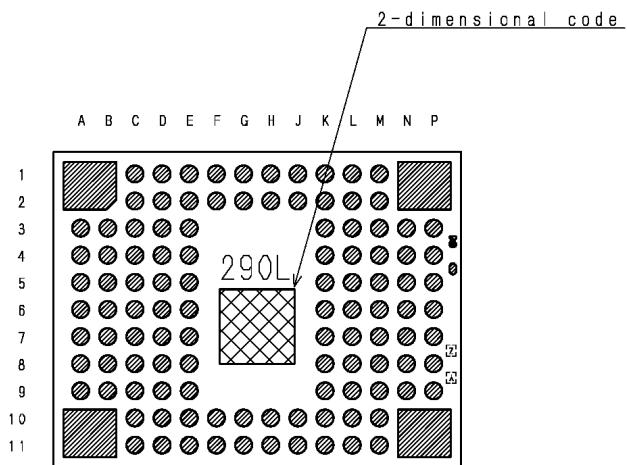
List of White Pixel, Black Pixel and Bright Pixel Pattern

No.	Pattern 	It provides by color filter array described in the left. Same color	White pixel Black pixel Bright pixel
1		Same color	Rejected
2		Same color	Rejected

- Note) 1. "●" shows the position of white pixel, black pixel and bright pixel.
White pixel, black pixel and bright pixel are specified separately according the pattern.
(Example: If a black pixel and a white pixel is in the pattern No.1 respectively, they are not judged to be rejected.)
2. When one or more spot pixels indicated "Rejected" is selected and removed.
3. Spot pixels other than described in the table above are all counted including the number of allowable spot pixels by zone.

Marking (Tentative)

Tentative drawing



Note: Following characters enter into "Y", and "Z". (No Au coat)
Y: In English upper case character, One character
Z: Number, single number

DRAWING No. AM-*290LQR (2D)

Notes On Handling

1. Static charge prevention

Image sensors are easily damaged by static discharge. Before handling be sure to take the following protective measures.

- (1) Either handle bare handed or use non-chargeable gloves, clothes or material.
Also use conductive shoes.
- (2) Use a wrist strap when handling directly.
- (3) Install grounded conductive mats on the floor and working table to prevent the generation of static electricity.
- (4) Ionized air is recommended for discharge when handling image sensors.
- (5) For the shipment of mounted boards, use boxes treated for the prevention of static charges.

2. Protection from dust and dirt

Image sensors are packed and delivered with care taken to protect the element glass surfaces from harmful dust and dirt. Clean glass surfaces with the following operations as required before use.

- (1) Perform all lens assembly and other work in a clean environment (class 1000 or less).
- (2) Do not touch the glass surface with hand and make any object contact with it.
If dust or other is stuck to a glass surface, blow it off with an air blower.
(For dust stuck through static electricity, ionized air is recommended.)
- (3) Clean with a cotton swab with ethyl alcohol if grease stained. Be careful not to scratch the glass.
- (4) Keep in a dedicated case to protect from dust and dirt. To prevent dew condensation, preheat or precool when moving to a room with great temperature differences.
- (5) When a protective tape is applied before shipping, remove the tape applied for electrostatic protection just before use. Do not reuse the tape.

3. Installing (attaching)

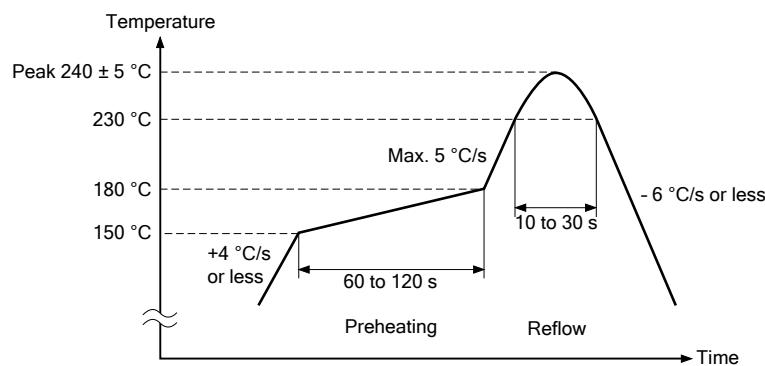
- (1) If a load is applied to the entire surface by a hard component, bending stress may be generated and the package may fracture, etc., depending on the flatness of the bottom of the package. Therefore, for installation, use either an elastic load, such as a spring plate, or an adhesive.
- (2) The adhesive may cause the marking on the rear surface to disappear.
- (3) If metal, etc., clash or rub against the package surface, the package may chip or fragment and generate dust.
- (4) Acrylate anaerobic adhesives are generally used to attach this product. In addition, cyanoacrylate instantaneous adhesives are sometimes used jointly with acrylate anaerobic adhesives to hold the product in place until the adhesive completely hardens. (Reference)
- (5) Note that the sensor may be damaged when using ultraviolet ray and infrared laser for mounting it.

4. Recommended reflow soldering conditions

The following items should be observed for reflow soldering.

(1) Temperature profile for reflow soldering

Control item	Profile (at part side surface)
1. Preheating	150 to 180 °C 60 to 120 s
2. Temperature up (down)	+4 °C/s or less (- 6 °C/s or less)
3. Reflow temperature	Over 230 °C 10 to 30 s Max. 5 °C/s
4. Peak temperature	Max. 240 ± 5 °C



(2) Reflow conditions

- (a) Make sure the temperature of the upper surface of the seal glass resin adhesive portion of the package does not exceed 245 °C.
- (b) Perform the reflow soldering only one time.
- (c) Finish reflow soldering within 72 h after unsealing the degassed packing.
Store the products under the condition of temperature of 30 °C or less and humidity of 70 % RH or less after unsealing the package.
- (d) Perform re-baking only one time under the condition at 125 °C for 24 h.

(3) Others

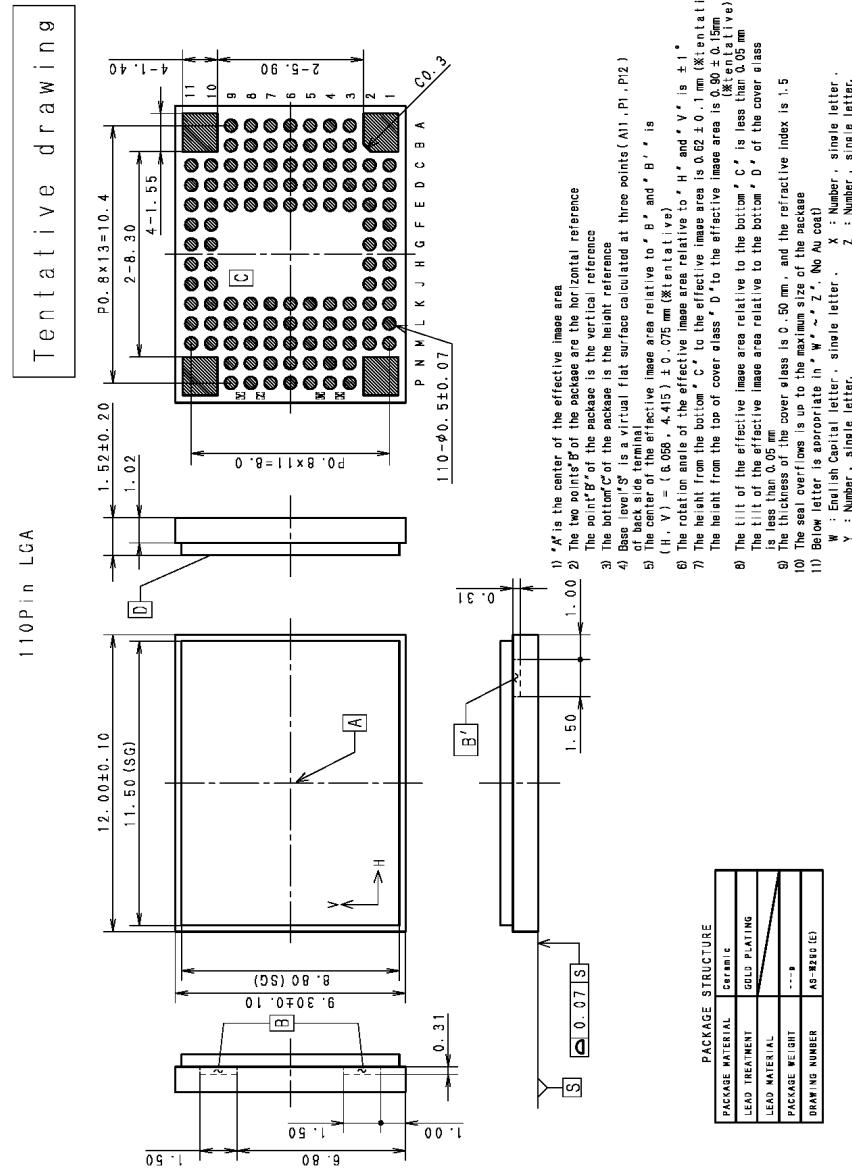
- (a) Carry out evaluation for the solder joint reliability in your company.
- (b) After the reflow, the paste residue of protective tape may remain around the seal glass.
(The paste residue of protective tape should be ignored except remarkable one.)
- (c) Note that X-ray inspection may damage characteristics of the sensor.

5. Others

- (1) Do not expose to strong light (sun rays) for long periods, as the color filters of color devices will be discolored.
- (2) Exposure to high temperature or humidity will affect the characteristics. Accordingly avoid storage or use in such conditions.
- (3) This product is precision optical parts, so care should be taken not to apply excessive mechanical shocks or force.
- (4) Note that imaging characteristics of the sensor may be affected when approaching strong electromagnetic wave or magnetic field during operation.
- (5) Note that image may be affected by the light leaked to optical black when using an infrared cut filter that has transparency in near infrared ray area during shooting subjects with high luminance.

Package Outline (Tentative)

(Unit: mm)



List of Trademark Logos and Definition Statements

* Exmor R is a trademark of Sony Corporation. The Exmor R is a Sony's CMOS image sensor with significantly enhanced imaging characteristics including sensitivity and low noise by changing fundamental structure of Exmor™ pixel adopted column parallel A/D converter to back-illuminated type.



* STARVIS is a trademark of Sony Corporation. The STARVIS is back-illuminated pixel technology used in CMOS image sensors for surveillance camera applications. It features a sensitivity of 2000 mV or more per $1 \mu\text{m}^2$ (color product, when imaging with a 706 cd/m^2 light source, F5.6 in 1 s accumulation equivalent), and realizes high picture quality in the visible-light and near infrared light regions.

Revision History

Date of change	Revision	Page	Contain of Change
5-Sep-14	0.1	-	First edition
24-Sep-14	0.2	1	Updated "Features"
24-Sep-14	0.2	8,12,14, 15,17,22, 41,50,51 56,63,70 77,83,84 86,89,90 94,95,96, 100,101,	correction of errors
30-Oct-14	0.3	35 to 48	Updated "Register Map"
30-Oct-14	0.3	56 to 58 63 to 65 70 to 72	correction of errors
30-Oct-14	0.3	80	Added Figure "Gain Reflection Timing"
12-Nov-14	0.4	102	Updated "Peripheral Circuit"
2-Feb-15	0.5	1	Updated "Features "
2-Feb-15	0.5	15	Updated "Current Consumption "
2-Feb-15	0.5	23	Updated "Spectral Sensitivity Characteristics "
2-Feb-15	0.5	24	Updated "Image Sensor Characteristics "
2-Feb-15	0.5	26	Updated "Measurement Method "
2-Feb-15	0.5	35 to 49	Updated "Register Map "
2-Feb-15	0.5	61	Updated "Drive Timing Chart "
2-Feb-15	0.5	57,58,64,65,71,72	Updated "List of Setting Register "
2-Feb-15	0.5	80	Updated "Gain Adjustment Function "
2-Feb-15	0.5	86	Updated "Example of Integration Time Settings "
2-Feb-15	0.5	104	Updated "Spot Pixel Specifications "
2-Feb-15	0.5	106	Updated "Measurement Method for Spot Pixels "