WiRobot™

The Heart of Robot

CAM3908 CMOS Mini Color Camera Head
User Manual

DrRobot®

Version: 1.0.0

APRIL 2005

Table of Contents

Related Document:

WiRobot PMB5010 Multimedia Controller User Manual

Dr.Robot® www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

1. Overview

This camera Module is designed for Mobile communication tools, which consists of CIF CMOS sensor and Digital signal processor to convert input video signal(digital) of CIF CMOS sensor to CIF/QCIF/QQCIF/QVGA/QQVGA formats.

1-1. Feature

- Thinner built-in lens CMOS imager with CIF resolution
  - Dedicated DSP by hard-wired logic with operating voltage of +2.5V±10%
  - Supply voltage +2.80V±0.2V
- Power consumption: typ. 45 mW at 15 fps
- Smaller and thinner size for built-in camera inside Mobile phone

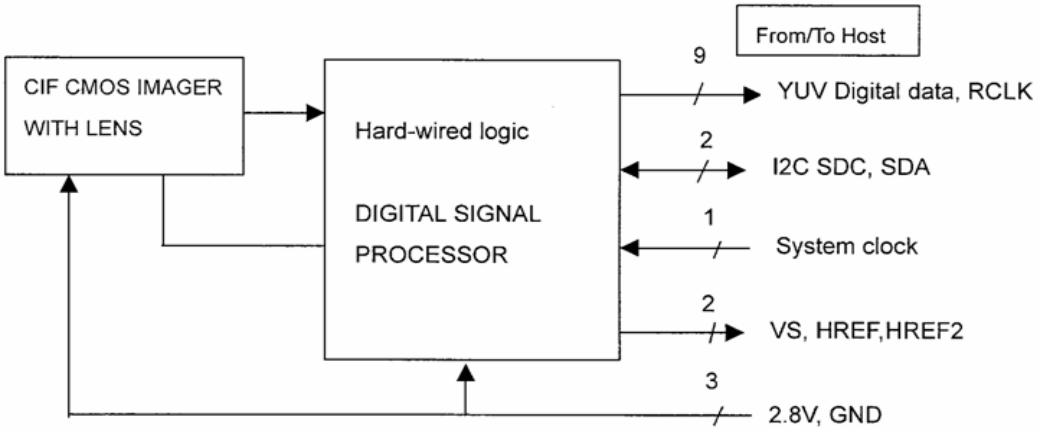
1-2. Function

- With CIF CMOS sensor, digital parallel output in CIF/QCIF/QQCIF/ QVGA/QQVGA format is available.
- UYVY digital parallel output is available.
- Includes the function of generating sync signal of CIF CMOS sensor.
- It is able to construct video camera only from this LSI and CIF CMOS sensor.
- It is able to change parameters, which is necessary for video signal processing.
- Auto exposure control is included.
- Auto white-balance control is included.
- Auto carrier-balance control is included..
- Auto correction of white defects is included.
- Shading correction control is included.

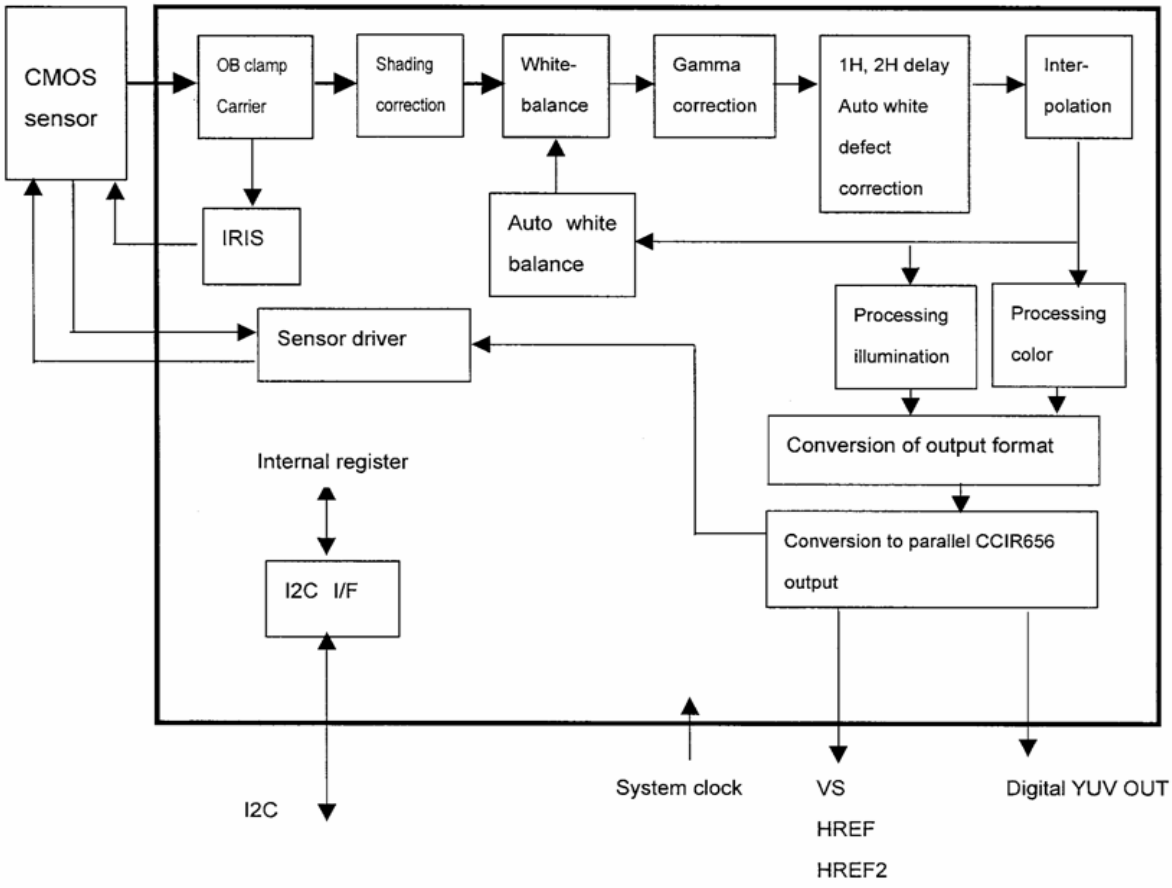
Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

2. CAMERA MODULE BLOCK DIAGRAM

Below shows block diagram of the CIF camera module .



2-1. Block diagram of DSP



Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

2-2. Pin assignment

NO	NAME	I/O	CONTENTS
1	GND	-	Ground
2	SCL	I/O	I2C Serial Clock
3	SDA	I/O	I2C Data
4	STDBY	I	Stand -by input
5	VS	OUT	Digital image vertical blank pulse output
6	NC	-	Non connection
7	NC	-	Non connection
8	AVDD	I	DC2.8V for CMOS sensor
9	NC	-	Non connection
10	NC	-	Non connection
11	RCLK2	OUT	Digital YUV signal separation signal output
12	NC	-	Non connection
13	NC	-	Non connection
14	CKI	I	System clock input (9MHz)
15	MITYPEZ	I	Camera serial device address select input
16	DAS	I	Camera serial DAS device address input
17	TEST4	I	Camera self-test input (Normal : Open)
18	VDD2	I	DC 2.8V for I/O pin
19	GND	-	Ground
20	RSTN	I	Camera reset input (Low active)
21	EEPINIT	I	EEPROM data auto loading enable/disable input
22	RCLK	O	Digital YUV signal synchronized clock output
23	HREF2	OUT	Digital image horizontal blank pulse output 2
24	HREF	OUT	Digital image horizontal blank pulse output
25	GND	-	Ground
26	OD0	OUT	Digital YUV-signal output(LSB)
27	OD1	OUT	Digital YUV-signal output
28	OD2	OUT	Digital YUV-signal output
29	OD3	OUT	Digital YUV-signal output
30	OD4	OUT	Digital YUV-signal output
31	OD5	OUT	Digital YUV-signal output
32	OD6	OUT	Digital YUV-signal output
33	OD7	OUT	Digital YUV-signal output (MSB)
34	NC	-	Non connection
35	NC	-	Non connection
36	VDD1	I	DC2.8V for DSP

Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

3. SIGNAL INTERFACE FORMATS

3-1 CAMERA CLOCK

Available input clock to this module is System_clk.
MODE1(clock selector) allows to select the clock to use.

3-1-1 SYSTEM CLK: 9MHz input

Input clock from outside is supplied to CMOS sensor through SCKO of DSP after dividing according to DSP_CTRL1[7:5](CLK_MODE). Examples are described in Table 3-1.

Table 3-1: Operation examples

CMOS Sensor	System_clk frequency	DSP_CTRL[7:5] (CLK_MODE)	CMOS sensor Clock frequency	Operation frame rate
CIF	9MHz	30fps(000): 1/1 clock	9MHz	30fps (NOTE)
		15fps(001): 1/2 clock	4.5MHz	15fps
		10fps(010): 1/3 clock	3MHz	10fps
		6fps(011): 1/5 clock	6MHz	6fps
		5fps(100): 1/6 clock	6MHz	5fps
		3fps(101): 1/10 clock	3MHz	3fps
		2fps(110): 1/15 clock	2MHz	2fps
		1fps(111): 1/30 clock	1MHz	1fps

(NOTE) Camera performance can not be guaranteed at 30 fps.

3-2 Digital Image output

3-2-1 Image format

In addition to CIF, shrink or cut out to QVGA/QQVGA/QCIF/QQCIF formats can be applied. Capture image size can be changed by capture start position(HCAPS, VCAPS) and capture end position(HCAPE, VCAPE). It is able to adapt to CIF sensor/CIF mode by setting of register MOS_CTRL1[7:6](MOS_TYPE).

Available settings are described table 3-2.

Processing image size			Image parameter	Output image size		
	Horizontal size	Vertical size	DSP_CTRL1[2:0] (RESIZE)		Horizontal size	Vertical size
CIF	352	288	X 1 (000)	CIF	352	288
CIF	352	288	X 1/2 (001)	QCIF	176	144
CIF	352	288	X 1/4 (010)	QQCIF	88	72
QCIF	176	144	X 1 (000)	QCIF	176	144
QCIF	176	144	X 1/2 (001)	QQCIF	88	72
QVGA	320	240	X 1 (000)	QVGA	320	240
QVGA	320	240	X 1/2 (001)	QQVGA	160	120

Table 3-2: Output conversion in using CIF sensor

Dr.Robot® www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

3-2-2 Parallel data output

Parallel output from data output pin with basically-complied CCIR=656 is available. It is able to adapt to CIF sensor/CIF mode by setting to the register MOS_CTRL1[7:6] (MOS_TYPE). And also adapt to YUV (each component is 8bits, YUV output: OUT_SEL = "00"), UYVY (each component is 8bits, UYVY output: OUT_SEL = "01"), RGB (each component 8bits, RGB output: OUT_SEL = "10") by setting to the register DSP_CTRL3[5:4] (OUT_SEL). Maximum frame rate is 15fps.

3-3 I2C interface

I2C interface of this LSI has the functions that can be read/written from external hosts.

After power-on, the LSI waits for register written from external hosts (WFLG=1).

SDA: Data I/O port from external hosts

SDC: Clock input from external hosts

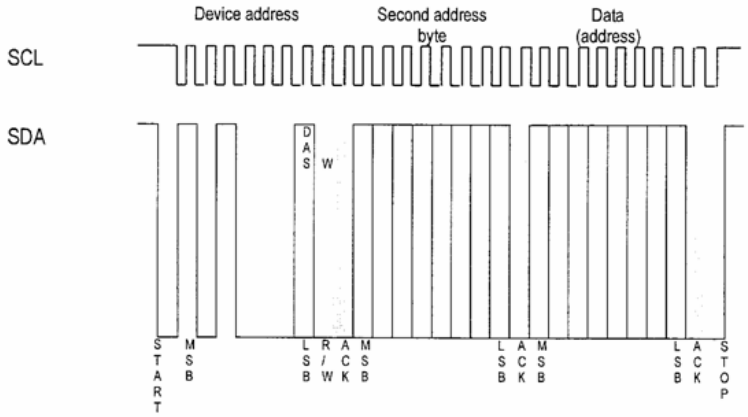
3-3-1 Camera module address

Device address from external hosts is shown in following.

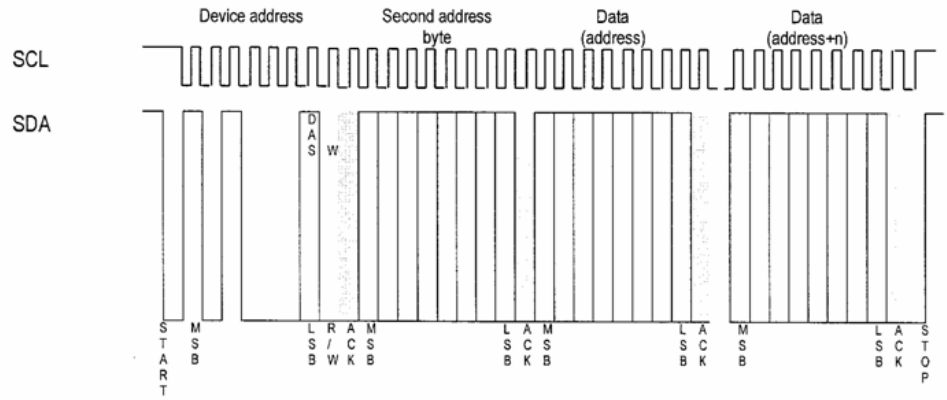
1	0	1	0	0	0	0	C0/C1
MSB						LSB	R/W

3-3-2 Write from external hosts

(1) Writing one Byte register (example)



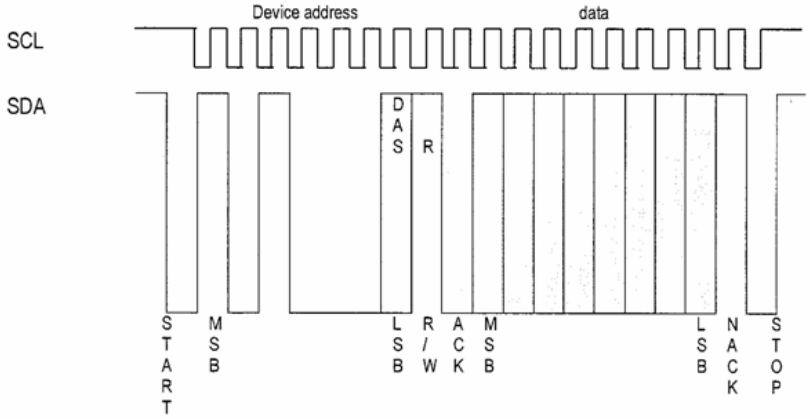
(2) Writing Block registers (example)



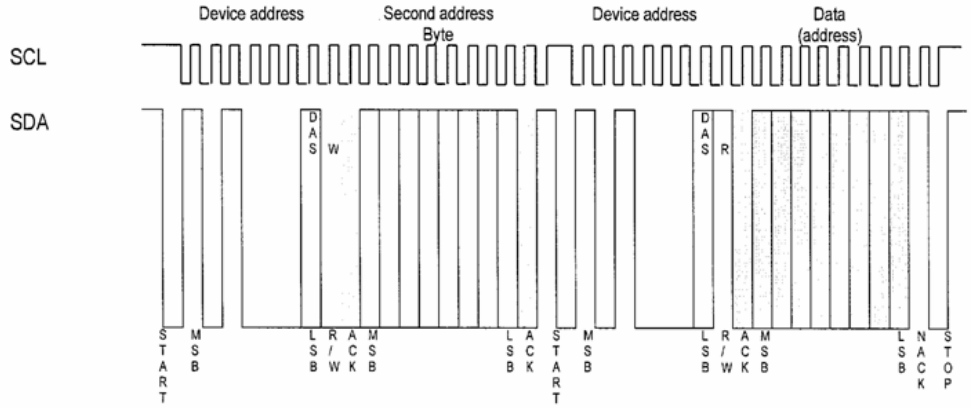
Dr.Robot® www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

3-3-3 Read to external hosts

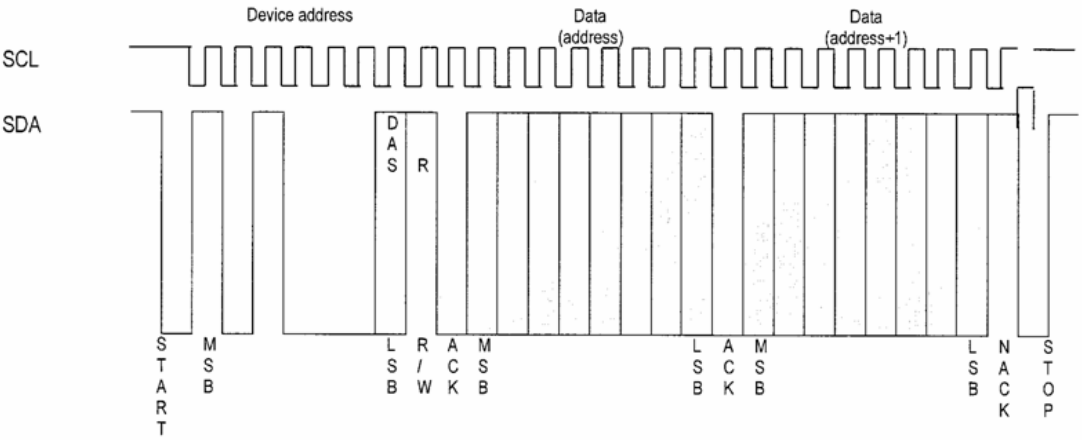
(1) Reading Current address register (example)



(2) Reading Random registers (example)



(3) Reading Sequential register (example)



(NOTE)

Below addresses range is not available to read with "Reading Sequential register".

RANGE 0X00EFh ~ 0X00FFh

Either "Reading Current register" or "Reading Random registers" is available to read out a data for addresses of 0X00EFh ~ 0X00FFh.

Dr.Robot® www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

4. CAMERA SYSTEM SPECIFICATIONS

4-1. Absolute Maximum Rating

Item	Symbol	Rated value	Unit	Note
Power supply voltage	2.8V	-0.3~4.3	V	AVDD,VDD1,VDD2
Input voltage	V_{I2}	-0.3~VDD+0.3	V	System_clk, SDA, SDC
Output voltage	V_{O1}	-0.3~VDD+0.3	V	YUVData, RCLK, VS, HREF

4-2. RECOMMENDED OPERATING CONDITION

Item	Symbol	MIN.	TYP.	MAX.	Unit	Note
Power supply voltage	2.8V	2.60	2.80	3.0	V	VDD
Operating temperature	T_{OPR}	-20	25	60	°C	
Storage temperature	T_{STG}	-20	25	70	°C	
Operating frequency	f_{OPR}	1.0	9.0	-	MHz	System_clk
Power consumption			45		mW	CIF at 15 fps
Standby Power consumption			TBD		mW	CIF at 15 fps
Operating humidity	H_{OPR}			TBD	%	never condense into dew

4-3. CAMERA PERFORMANCE

Items	Specification				
	Min.	Typ.	Max.	Unit	Others
Horizontal Resolution	150			TV-line	Image center
γ correction		0.45		--	Adjustable by I2C
Fastest Electronic shutter speed		1/9,900		sec	
Slowest Electronic shutter speed		1		sec	
Image SN	43 (TBD)			dB	Adjustable by I2C
Image Dynamic range	57 (TBD)			dB	Adjustable by I2C
Minimum object illumination (25°C)			10	lux	at 15 fps
Low object illumination (40°C)			100	lux	at 15 fps
Maximum object illumination (25°C)	50,000			lux	at 15 fps
AGC maximum gain		20 (TBD)		dB	Adjustable by I2C
AGC minimum gain		3 (TBD)		dB	Adjustable by I2C
Maximum color temperature by AWB		100000		degree K	Adjustable by I2C
Minimum color temperature by AWB		2500		degree K	Adjustable by I2C
Maximum Frame rate		15		fps	
Minimum Frame rate		1		fps	

Dr.Robot® www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

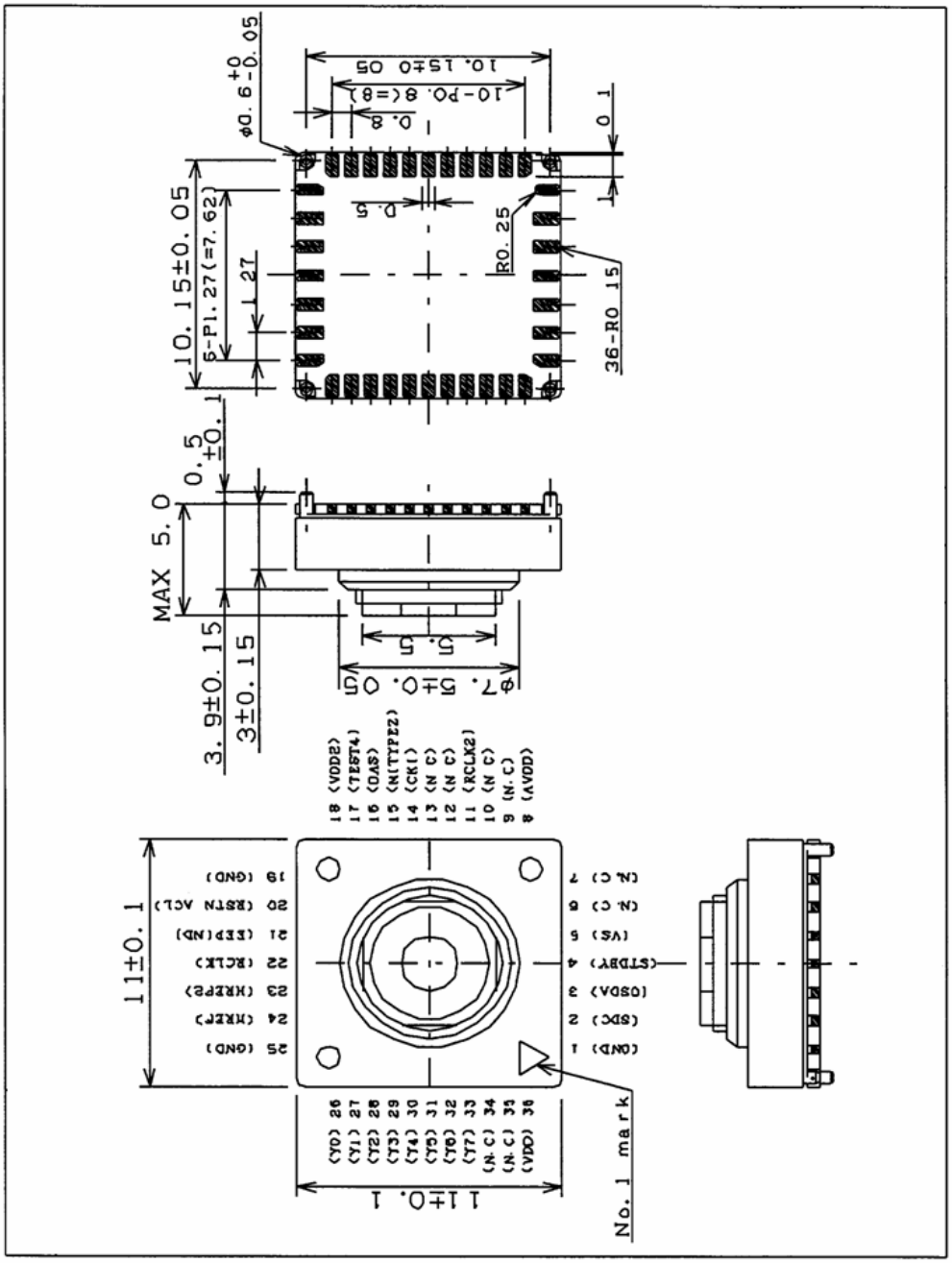
4-4. OPTICAL PERFORMANCE

ITEM	CHARACTERISTICS	OTHERS
Number of Lens elements	Aspheric single lens	for 1/7"
Material of Lens element	Higher heat-proof plastic	
View angle in Horizontal	typ. 58deg.	for the image area of H2.06mm × V1.63mm (D2.63mm)
View angle in Vertical	typ. 46 deg.	
View angle in Diagonal	typ. 73 deg.	
Image circle	Approx. ∅2.63mm Effective circle ∅2.63mm	
Focal length	2.0 mm ± 5 %	
F number	2.8 ± 5 %	
Image distortion	Approx. -4.0 % at the edge of Image	TV distortion
Focus range	20 cm – Infinity	
MTF center	80 LP/mm	at MTF 30%
circumference (70%)	45 LP/mm	at MTF 30%
Material of Lens holder	Plastic PPS (GF30%)	
Material to support Lens Barrel	Plastic PC (GF20%)	
IR cut filter	Spattered on glass lid	
Optical LPF	not built-in	

Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

4-5. MECHANICAL SPECIFICATION

4-5-1. Dimensions



Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

5. ELECTRICAL CHARACTERISTICS

5-1. DC Characteristics

(VDD = +2.80V Ta = -10°C ~ 60°C)

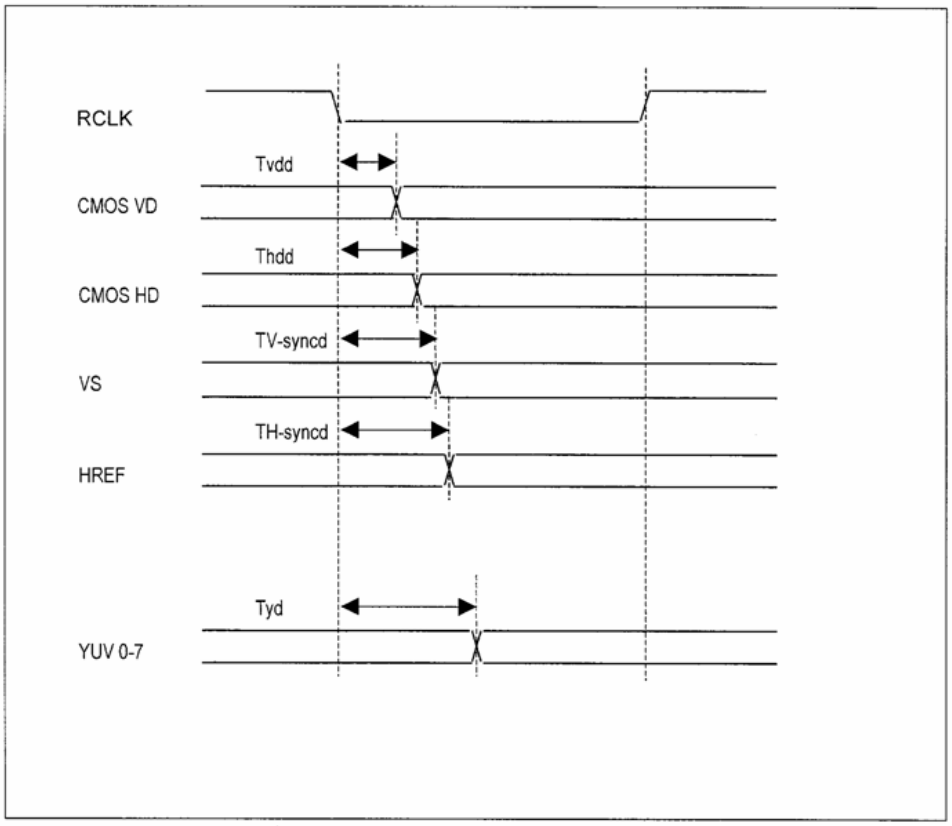
Item	Symbol	Test condition	MIN.	TYP.	MAX.	Unit	Note
Low level input voltage1	V_{IL1}				0.3VDD	V	1
High level input voltage1	V_{IH1}		0.7VDD			V	
Low level input voltage2	V_{IL2}				0.2VDD	V	2
High level input voltage2	V_{IH2}		0.8VDD			V	
Hysteresis voltage	V_{HYS}		0.1VDD			V	3
Input leak current 1	I_{I1}	V_{IN} = 0V ~ V_{DD}	-1.0		+1.0	μA	4
Input leak current 2	I_{I2}	V_{IN} = 0V ~ V_{DD}	-1.0		+1.0	μA	5
Low level output voltage1	V_{OL1}	I_{OL} = 3mA			0.2VDD	V	6
Low level output voltage1	V_{OL2}	I_{OL} = 3mA			0.5	V	7
High level output voltage1	V_{OH2}	I_{OL} = -3mA	VDD-0.5			V	
Clock frequency	$F_{Sync\ clk}$		1	9	10	MHz	8
Clock input voltage	$V_{Sync\ clk}$			2.8		Vp-p	

NOTE	COMMENT
1	Applicable to pin SDA, SDC
2	Applicable to pin YUVData 0-7
3	Applicable to pin SDA, SDC
4	Applicable to pin SDA, SDC
5	Applicable to pin YUVData 0-7
6	Applicable to pin SDA, SDC
7	Applicable to pin YUVData 0-7, RCLK, VS, HREF
8	Applicable to pin System_clock

Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

5-2. AC Characteristics

5-2-1. Digital parallel output timing



(V_{DD} = +2.78V Ta = -10°C ~ 60°C)

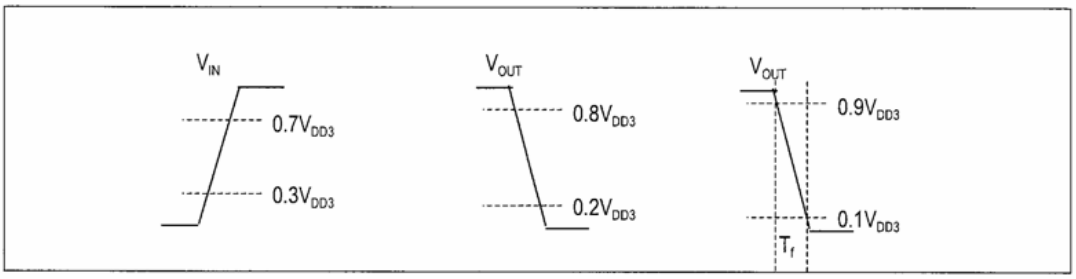
Item	Symbol	Condition		Unit	Note
		MIN	MAX		
CMOS imager VD output delay	Tvdd	-15	15	ns	1
CMOS imager HD output delay	Thdd	-15	15	ns	1
VS output delay	TV-sync	-15	15	ns	1
HREF output delay	TH-sync	-15	15	ns	1
YUVData 0-7 output delay	Tyd	-15	15	ns	1

(Note 1) Output load capacitance CL = 15pF

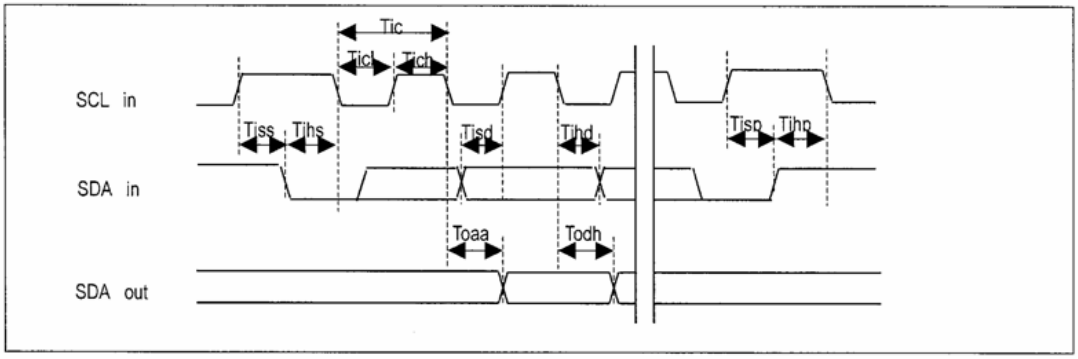
Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

5-2-2. I2C interface timing

I/O level, rising time



Host I/F timing



(VDD= +2.78V Ta = -10°C ~ 60°C)

Item	Symbol	MIN	MAX	UNIT	Note
Operating clock frequency	Tic		400	kHz	
Period that clock is High.	Tich	0.1		µs	
Period that clock is Low.	Ticl	0.2		µs	
Setup time of start condition.	Tiss	0.1		µs	
Hold time of start condition.	Tihs	0.1		µs	
Setup time of input data.	Tisd	0.1		µs	
Hold time of input data.	Tihd	0		µs	
Output delay	Toaa	0		µs	1
Hold time of output data.	Todh	0		µs	1
Setup time of stop condition.	Tisp	0.1		µs	
Hold time of stop condition.	Tihp	0.1		µs	
Period of rising	Tf		300	ns	1

(Note 1) Output load capacitance CL = 15pF.

Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

6. Function guide

6-1-1. Auto exposure control

Control variable speed electronic shutter and gain of AGC (Auto Gain Control), so that exposure data can converge in standard. When the exposure data converge in error range of exposure control, shutter control and gain control of AGC will halt, until they exceed the range. When the exposure data exceed error range of exposure control, shutter control and gain control of AGC will be continued, until they converge in the range. And this LSI also has "Back light correction", "variable exposure weight control", "switching auto/fixed exposure control", "variable speed of exposure control", "variable max shutter speed in auto exposure control", "variable LPF used in auto exposure control loops".

6-1-2. Auto optical black level adjustments

It is able to switch auto/fixed control of auto optical black level, and LPF used in control loops.

6-1-3. Auto carrier balance control

Automatic carrier balance correction is available. It is able to select "auto control + correction by fixed value" or "correction by fixed value.

6-1-4. Auto white balance control

R and B signal are multiplied by each factor to control white balance. When white balanced data converge in defined range 1, control would halt, until they exceed defined range 2. When white balanced data exceed defined range 2, control would be continued until they converge in defined range 1. It is able to switch to fast white balance mode and change LPF of white balance, too.

6-1-5 Color suppression

This function can suppress false color seen at the edge of luminance signals and at high luminance level areas, and suppress color signals at low luminance level areas. And color signal is suppressed synchronized with change of AGC gain.

6-1-6. AGC aperture suppression

It is able to suppress aperture signal synchronized with change of AGC gain.

Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197

6-1-7. Property of gamma

Gamma correction can be applied by the curve approximated to 10 line graphs.

Slope and offset of line graphs can be configured.

6-1-8 White defect correction

Fixed white defect correction (less than 32 points) and auto white defect correction can be applied. It is able to switch to use auto and fixed correction, or use only fixed correction.

6-1-9 Shading correction

It is able to correct the shading at corner of the image, which is caused by optical characteristics of lens. It is able to select using shading correction or not.

6-1-10. Procedure for setting parameters on booting

After Power-on, this Camera module will have booted as "slave mode", and parameter will be set by host connected to SDC (clock for I^2C), SDA(data for I^2C).

6-1-11. About standby mode

Standby mode means the status that MOS_CTRL2[3](MOS_STDBY) is '1'.

In this status, the internal LSI halts all function, except I^2C interface control, and CSTDBYO goes High level in order to let CMOS sensor go standby. Not in standby mode, CSTDBYO is Low level.

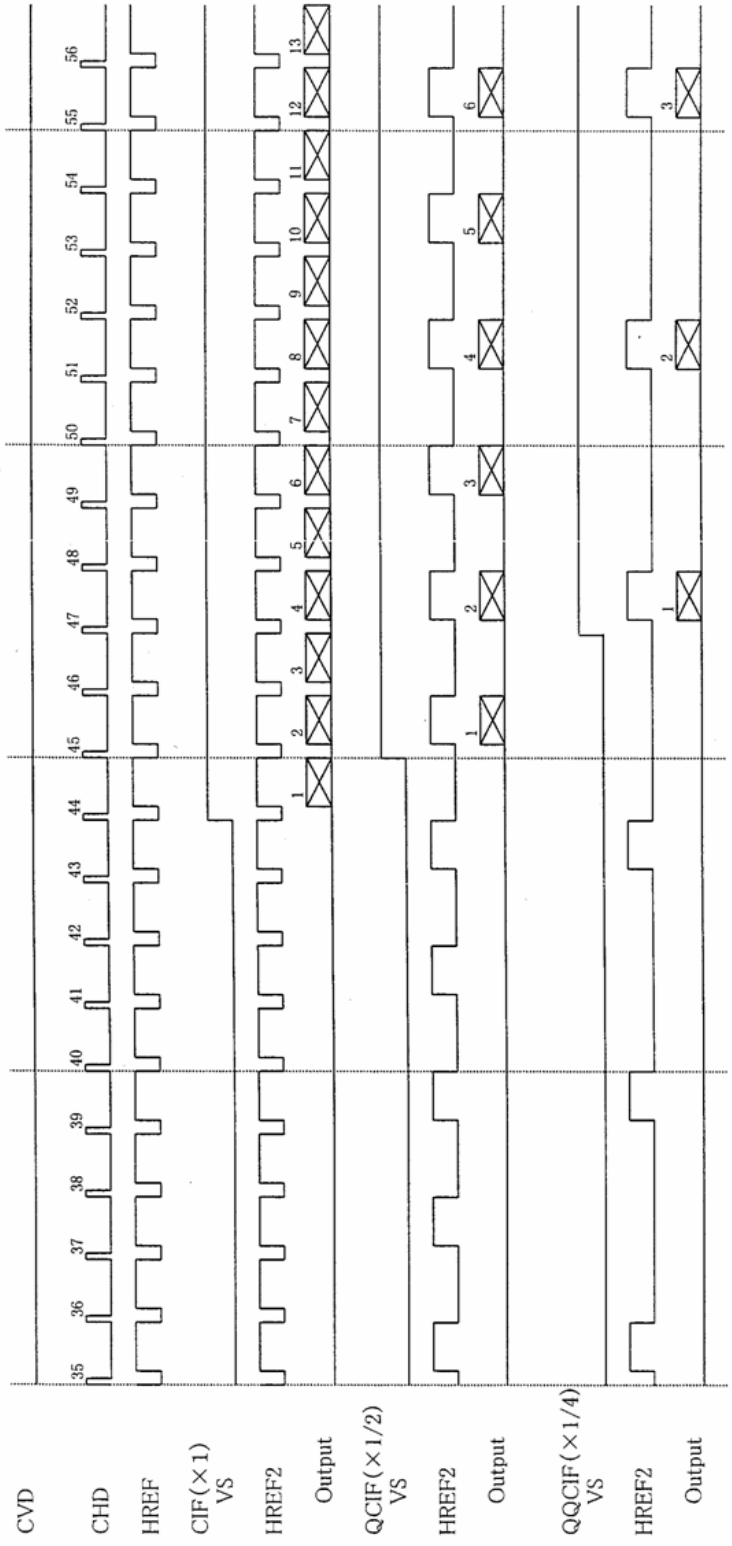
Return procedures from standby mode to normal mode are described below.

Procedure 1: When MOS_CTRL2[3] is '1'.

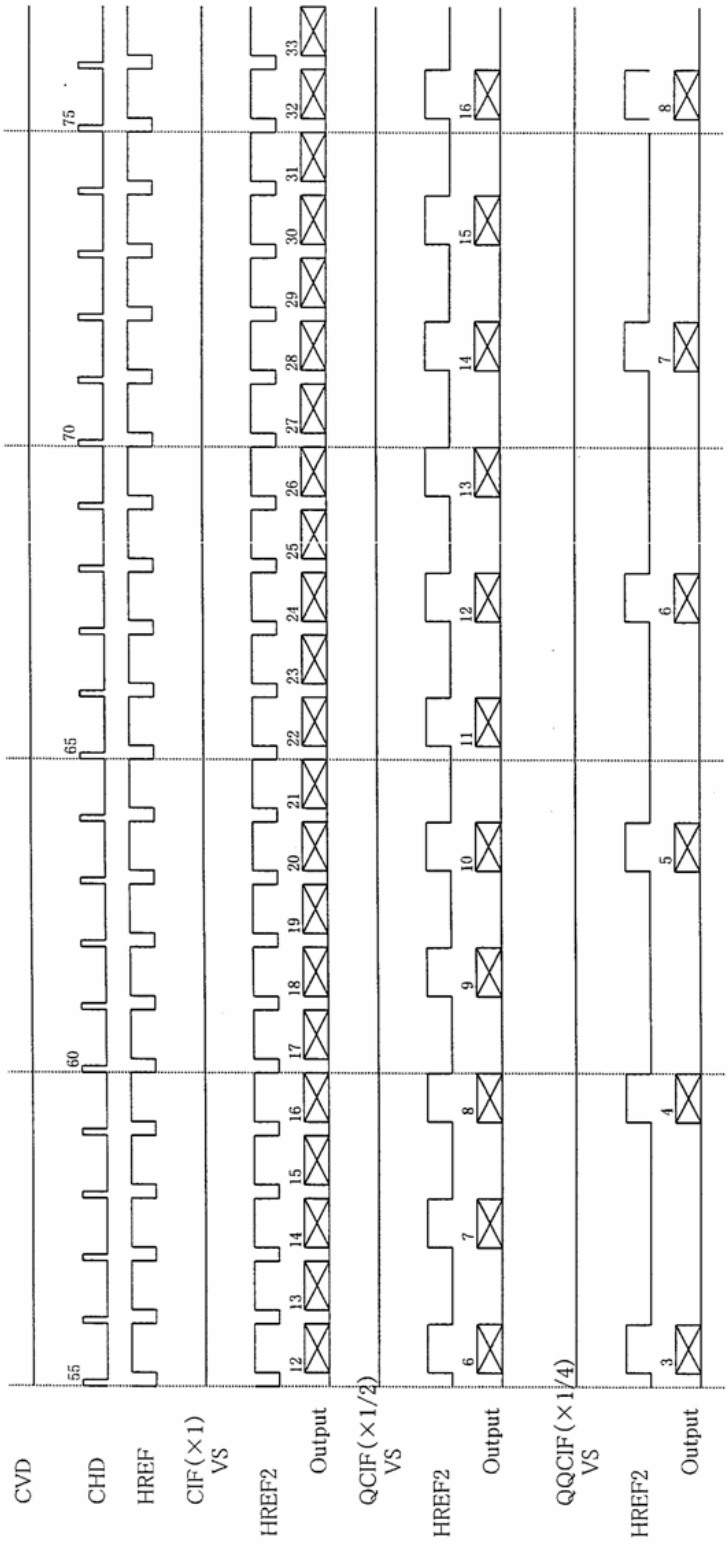
1 Set DSP_ENB[1](FWFLG) to '0' and DSP_ENB[0](WFLG) to '0'.
2 Set MOS_CTRL2[3] to '0'.
3 Set DSP_ENB[1] to '0' and DSP_ENB[0] to '1'.
4 Camera returns to normal mode after the time configured in STDBY_TIM.

Procedure 2: When MOS_CTRL2[3] is '1'.

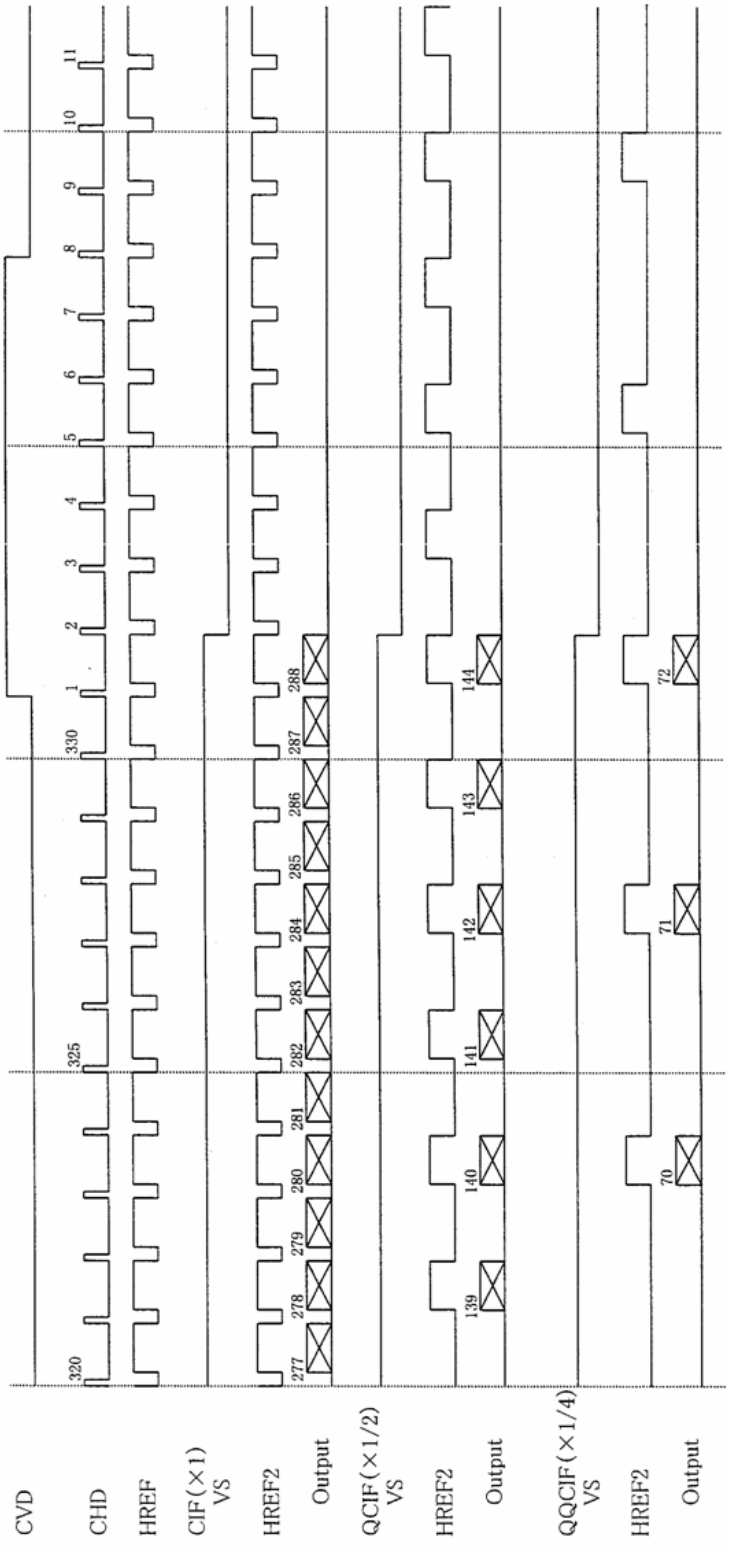
1 Set MOS_CTRL2[3] to '0'.
2 Set DSP_ENB[1] to '1'.
3 Camera returns to normal mode after the time configured in STDBY_TIM.



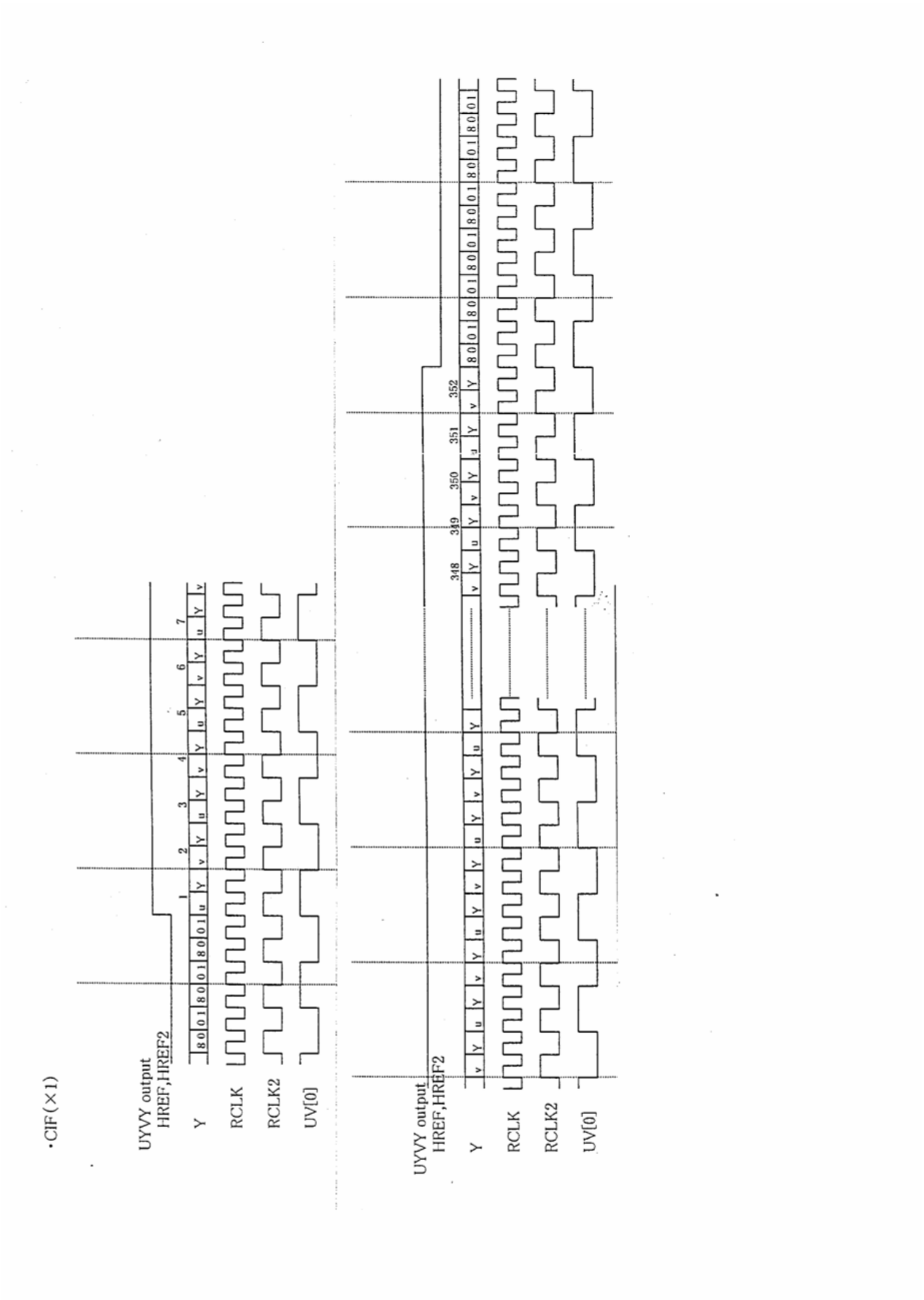
Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197



Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197



Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197



Dr.Robot®
www.DrRobot.com
25 Valleywood Dr., Unit 20, Markham, ON, L3R 5L9 Canada Tel: (905) 943-9572 Fax: (905) 943-9197