OV7670/OV7171 CMOS VGA (640x480) CAMERACHIP™ with OmniPixel® Technology

General Description

The OV7670/OV7171 CAMERACHIP™ is a low voltage CMOS image sensor that provides the full functionality of a single-chip VGA camera and image processor in a small footprint package. The OV7670/OV7171 provides full-frame, sub-sampled or windowed 8-bit images in a wide range of formats, controlled through the Serial Camera Control Bus (SCCB) interface.

This product has an image array capable of operating at up to 30 frames per second (fps) in VGA with complete user control over image quality, formatting and output data transfer. All required image processing functions, including exposure control, gamma, white balance, color saturation, hue control and more, are also programmable through the SCCB interface. In addition, OmniVision CAMERACHIPS use proprietary sensor technology to improve image quality by reducing or eliminating common lighting/electrical sources of image contamination, such as fixed pattern noise (FPN), smearing, blooming, etc., to produce a clean, fully stable color image.

Note: The OV7670/OV7171 uses a lead-free package.

Features

- High sensitivity for low-light operation
- Low operating voltage for embedded portable apps
- Standard SCCB interface compatible with I2C interface
- Supports VGA, CIF, and resolutions lower than CIF for RGB (GRB 4:2:2, RGB565/555), YUV (4:2:2) and YCbCr (4:2:2) formats
- VarioPixel® method for sub-sampling
- Automatic image control functions including: Automatic Exposure Control (AEC), Automatic Gain Control (AGC), Automatic White Balance (AWB), Automatic Band Filter (ABF), and Automatic Black-Level Calibration (ABLC)
- Image quality controls including color saturation, hue, gamma, sharpness (edge enhancement), and anti-blooming
- ISP includes noise reduction and defect correction
- Supports LED and flash strobe mode
- Supports scaling
- Lens shading correction
- Flicker (50/60 Hz) auto detection
- Saturation level auto adjust (UV adjust)
- Edge enhancement level auto adjust
- De-noise level auto adjust

Ordering Information

Product	Package
OV07670-VL2A (Color, lead-free)	24 pin CSP2
OV07171-VL2A (B&W, lead-free)	24 pin CSP2

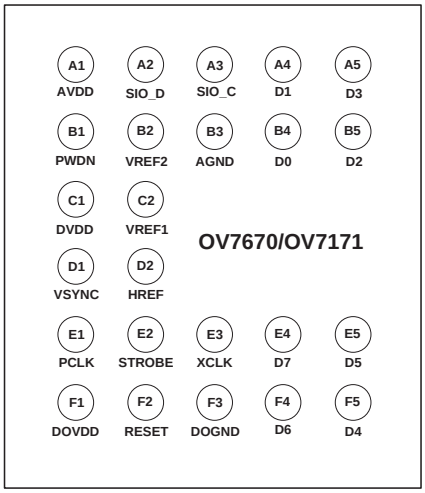
Applications

- Cellular and Picture Phones
- Toys
- PC Multimedia
- Digital Still Cameras

Key Specifications

Array Element (VGA)		640 x 480
Power Supply	**Digital Core**	1.8VDC ±10%
	Analog	2.45V to 3.0V
	I/O	1.7V to 3.0V
Power Requirements	**Active**	TBD
	Standby	< 20 µA
Temperature Range	**Operation**	-30°C to 70°C
	Stable Image	0°C to 50°C
Output Formats (8-bit)		• YUV/YCbCr 4:2:2 • RGB565/555 • GRB 4:2:2 • Raw RGB Data
Lens Size		1/6"
Chief Ray Angle		24°
Maximum Image Transfer Rate		30 fps for VGA
Sensitivity		1.1 V/Lux-sec
S/N Ratio		40 dB
Dynamic Range		TBD
Scan Mode		Progressive
Electronics Exposure		Up to 510:1 (for selected fps)
Pixel Size		3.6 µm x 3.6 µm
Dark Current		12 mV/s at 60°C
Well Capacity		17 K e
Image Area		2.36 mm x 1.76 mm
Package Dimensions		3785 µm x 4235 µm

Figure 1 OV7670/OV7171 Pin Diagram (Top View)



Functional Description

Figure 2 shows the functional block diagram of the OV7670/OV7171 image sensor. The OV7670/OV7171 includes:

- Image Sensor Array (total array of 656 x 488 pixels, with active pixels 640 x 480 in YUV mode)
- Analog Signal Processor
- A/D Converters
- Test Pattern Generator
- Digital Signal Processor (DSP)
- Image Scaler
- Timing Generator
- Digital Video Port
- SCCB Interface
- LED and Strobe Flash Control Output

Figure 2 Functional Block Diagram

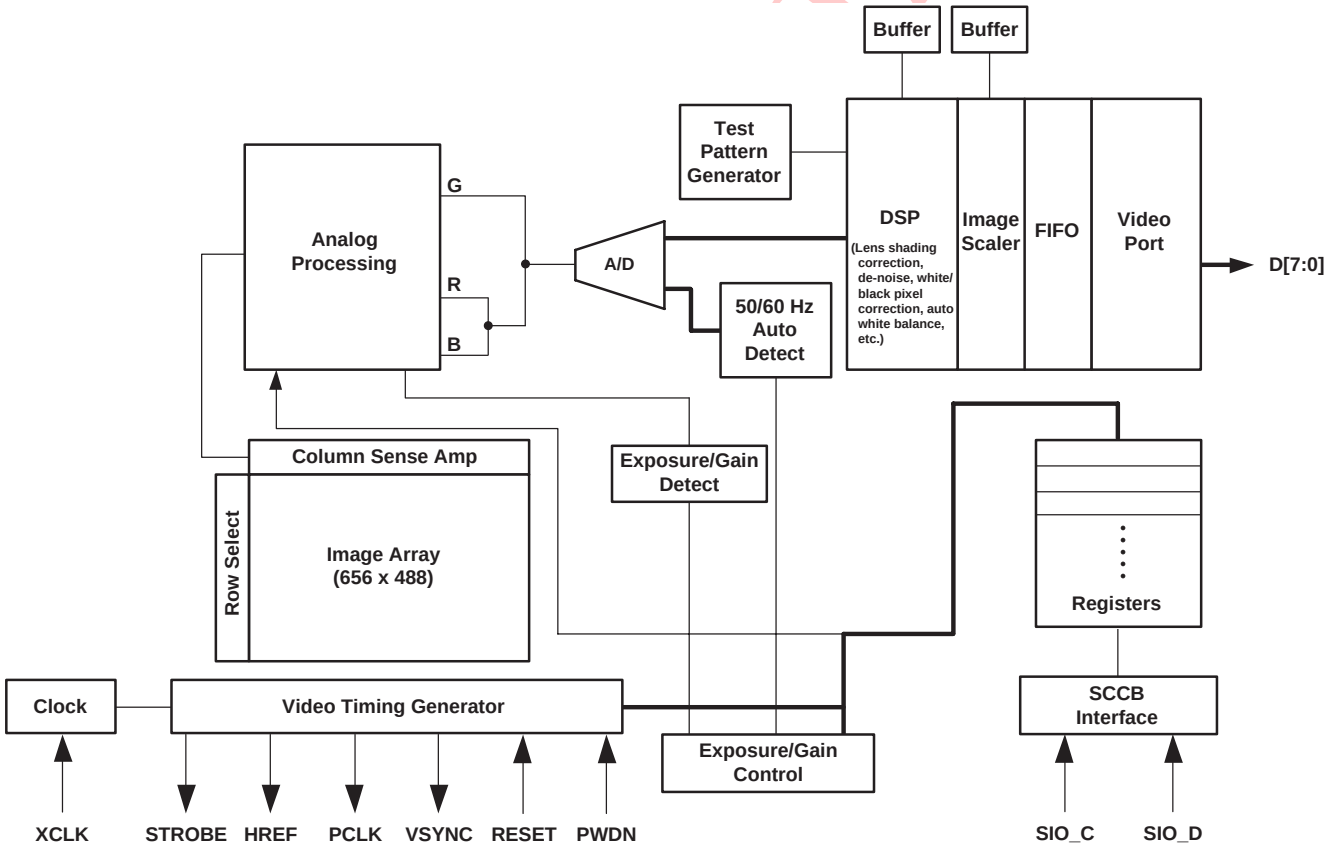
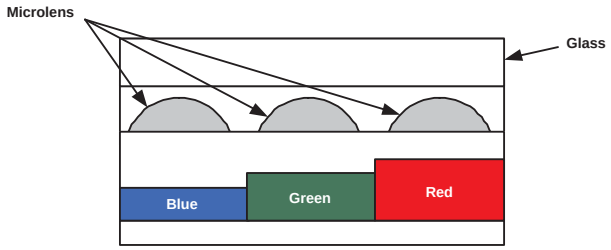


Image Sensor Array

The OV7670/OV7171 sensor has an image array of 656 x 488 pixels for a total of 320,128 pixels, of which 640 x 480 pixels are active (307,200 pixels). Figure 3 shows a cross-section of the image sensor array.

Figure 3 Image Sensor Array



Timing Generator

In general, the timing generator controls the following functions:

- Array control and frame generation
- Internal timing signal generation and distribution
- Frame rate timing
- Automatic Exposure Control (AEC)
- External timing outputs (VSYNC, HREF/HSYNC, and PCLK)

Analog Signal Processor

This block performs all analog image functions including:

- Automatic Gain Control (AGC)
- Automatic White Balance (AWB)

A/D Converters

After the Analog Processing block, the bayer pattern Raw signal is fed to a 10-bit analog-to-digital (A/D) converter shared by G and BR channels. This A/D converter operates at speeds up to 12 MHz and is fully synchronous to the pixel rate (actual conversion rate is related to the frame rate).

In addition to the A/D conversion, this block also has the following functions:

- Digital Black-Level Calibration (BLC)
- Optional U/V channel delay
- Additional A/D range controls

In general, the combination of the A/D Range Multiplier and A/D Range Control sets the A/D range and maximum value to allow the user to adjust the final image brightness as a function of the individual application.

Test Pattern Generator

The Test Pattern Generator features the following:

- 8-bar color bar pattern
- Fade-to-gray color bar pattern
- Shift "1" in output pin

Digital Signal Processor (DSP)

This block controls the interpolation from Raw data to RGB and some image quality control.

- Edge enhancement (a two-dimensional high pass filter)
- Color space converter (can change Raw data to RGB or YUV/YCbCr)
- RGB matrix to eliminate color cross talk
- Hue and saturation control
- White/black pixel correction
- De-noise
- Lens shading correction
- Programmable gamma control
- Transfer 10-bit data to 8-bit

Image Scaler

This block controls all output and data formatting required prior to sending the image out. This block scales YUV/RGB output from VGA to CIF and almost any size under CIF.

Digital Video Port

Register bits COM2[1:0] increase I_{OL}/I_{OH} drive current and can be adjusted as a function of the customer's loading.

SCCB Interface

The Serial Camera Control Bus (SCCB) interface controls the CAMERACHIP operation. Refer to *OmniVision Technologies Serial Camera Control Bus (SCCB) Specification* for detailed usage of the serial control port.

LED and Strobe Flash Control Output

The OV7670/OV7171 has a Strobe mode that allows it to work with an external flash and LED.

Pin Description

Table 1 Pin Description

Pin Number	Name	Pin Type	Function/Description
A1	AVDD	Power	Analog power supply
A2	SIO_D	I/O	SCCB serial interface data I/O
A3	SIO_C	Input	SCCB serial interface clock input
A4	D1[a]	Output	YUV/RGB video component output bit[1]
A5	D3	Output	YUV/RGB video component output bit[3]
B1	PWDN	Input (0)[b]	Power Down Mode Selection 0: Normal mode 1: Power down mode
B2	VREF2	Reference	Reference voltage - connect to ground using a 0.1 µF capacitor
B3	AGND	Power	Analog ground
B4	D0	Output	YUV/RGB video component output bit[0]
B5	D2	Output	YUV/RGB video component output bit[2]
C1	DVDD	Power	Power supply (+1.8 VDC) for digital logic core
C2	VREF1	Reference	Reference voltage - connect to ground using a 0.1 µF capacitor
D1	VSYNC	Output	Vertical sync output
D2	HREF	Output	HREF output
E1	PCLK	Output	Pixel clock output
E2	STROBE	Output	LED/strobe control output
E3	XCLK	Input	System clock input
E4	D7	Output	YUV/RGB video component output bit[7]
E5	D5	Output	YUV/RGB video component output bit[5]
F1	DOVDD	Power	Digital power supply for I/O (1.7V ~ 3.0V)
F2	RESET	Input (0)	Clears all registers and resets them to their default values. 0: Normal mode 1: Reset mode
F3	DOGND	Power	Digital ground
F4	D6	Output	YUV/RGB video component output bit[6]
F5	D4	Output	YUV/RGB video component output bit[4]

a. D[7:0] for 8-bit YUV or RGB (D[7] MSB, D[0] LSB)

b. Input (0) represents an internal pull-down resistor.

Electrical Characteristics

Table 2 Absolute Maximum Ratings

Ambient Storage Temperature		-40ºC to +95ºC
Supply Voltages (with respect to Ground)	**V_{DD-A}**	4.5 V
	V_{DD-C}	3 V
	V_{DD-IO}	4.5 V
All Input/Output Voltages (with respect to Ground)		-0.3V to V_{DD-IO}+0.5V
Lead-free Temperature, Surface-mount process		245ºC
ESD Rating, Human Body model		2000V

NOTE: Exceeding the Absolute Maximum ratings shown above invalidates all AC and DC electrical specifications and may result in permanent device damage.

Table 3 DC Characteristics (-30°C < T_A < 70°C)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
V_{DD-A}	DC supply voltage – Analog	–	2.45	2.75	3.0	V
V_{DD-C}	DC supply voltage – Digital Core	–	1.62	1.8	1.98	V
V_{DD-IO}	DC supply voltage – I/O power	–	1.7	–	3.0V	V
I_{DDA}	Active (Operating) Current	See Note [a]		10 + 8[b]		mA
$I_{DDS-SCCB}$	Standby Current	See Note [c]		1		mA
$I_{DDS-PWDN}$	Standby Current			10	20	µA
V_{IH}	Input voltage HIGH	CMOS	0.7 x V_{DD-IO}			V
V_{IL}	Input voltage LOW				0.3 x V_{DD-IO}	V
V_{OH}	Output voltage HIGH	CMOS	0.9 x V_{DD-IO}			V
V_{OL}	Output voltage LOW				0.1 x V_{DD-IO}	V
I_{OH}	Output current HIGH	See Note [d]	8			mA
I_{OL}	Output current LOW		15			mA
I_L	Input/Output Leakage	GND to V_{DD-IO}			± 1	µA

a. V_{DD-A} = 2.5V, V_{DD-C} = 1.8V, V_{DD-IO} = 2.5V
$I_{DDA} = \Sigma\{I_{DD-IO} + I_{DD-C} + I_{DD-A}\}$, f_{CLK} = 24MHz at 30 fps YUV output, no I/O loading

b. I_{DD-C} = 10mA, I_{DD-A} = 8mA, without loading

c. V_{DD-A} = 2.5V, V_{DD-C} = 1.8V, V_{DD-IO} = 2.5V
$I_{DDS-SCCB}$ refers to a SCCB-initiated Standby, while $I_{DDS-PWDN}$ refers to a PWDN pin-initiated Standby

d. Standard Output Loading = 25pF, 1.2KΩ

Table 4 Functional and AC Characteristics (-30°C < T_A < 70°C)

Symbol	Parameter	Min	Typ	Max	Unit
Functional Characteristics					
	A/D Differential Non-Linearity		± 1/2		LSB
	A/D Integral Non-Linearity		± 1		LSB
	AGC Range			30	dB
	Red/Blue Adjustment Range			12	dB
Inputs (PWDN, CLK, RESET)					
f_{CLK}	Input Clock Frequency	10	24	48	MHz
t_{CLK}	Input Clock Period	21	42	100	ns
$t_{CLK:DC}$	Clock Duty Cycle	45	50	55	%
$t_{S:RESET}$	Setting time after software/hardware reset			1	ms
$t_{S:REG}$	Settling time for register change (10 frames required)			300	ms
SCCB Timing (see Figure 4)					
f_{SIO_C}	Clock Frequency			400	KHz
t_{LOW}	Clock Low Period	1.3			µs
t_{HIGH}	Clock High Period	600			ns
t_{AA}	SIO_C low to Data Out valid	100		900	ns
t_{BUF}	Bus free time before new START	1.3			µs
$t_{HD:STA}$	START condition Hold time	600			ns
$t_{SU:STA}$	START condition Setup time	600			ns
$t_{HD:DAT}$	Data-in Hold time	0			µs
$t_{SU:DAT}$	Data-in Setup time	100			ns
$t_{SU:STO}$	STOP condition Setup time	600			ns
t_R, t_F	SCCB Rise/Fall times			300	ns
t_{DH}	Data-out Hold time	50			ns
Outputs (VSYNC, HREF, PCLK, and D[7:0] (see Figure 5, Figure 6, Figure 7, Figure 9, and Figure 10)					
t_{PDV}	PCLK[↓] to Data-out Valid			5	ns
t_{SU}	D[7:0] Setup time	15			ns
t_{HD}	D[7:0] Hold time	8			ns
t_{PHH}	PCLK[↓] to HREF[↑]	0		5	ns
t_{PHL}	PCLK[↓] to HREF[↓]	0		5	ns
AC Conditions:	• V_{DD}: V_{DD-C} = 1.8V, V_{DD-A} = 2.5V, V_{DD-IO} = 2.5V • Rise/Fall Times: I/O: 5ns, Maximum SCCB: 300ns, Maximum • Input Capacitance: 10pf • Output Loading: 25pF, 1.2KΩ to 2.5V • f_{CLK}: 24MHz				

Timing Specifications

Figure 4 SCCB Timing Diagram

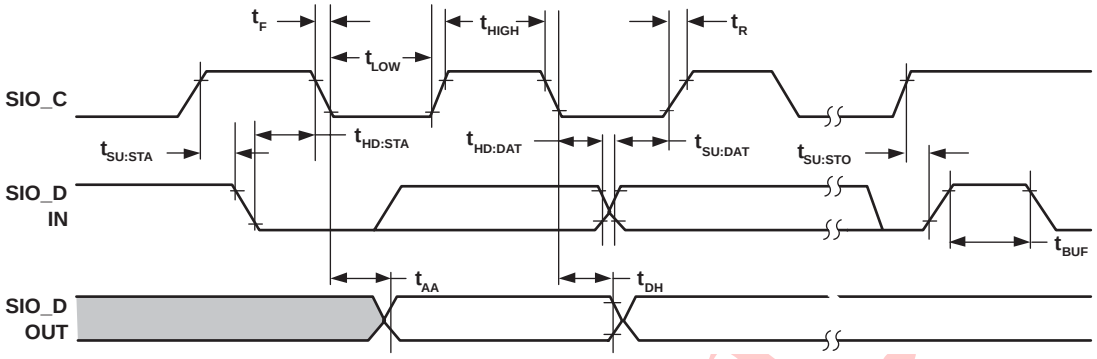


Figure 5 Horizontal Timing

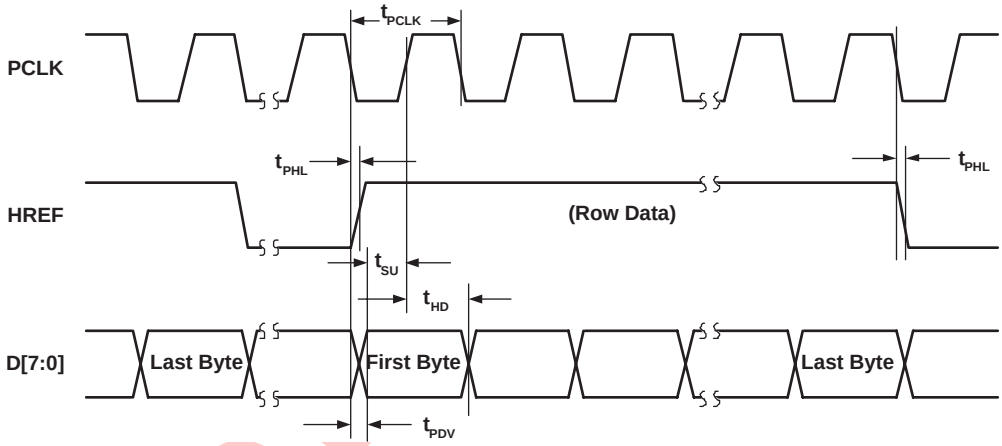
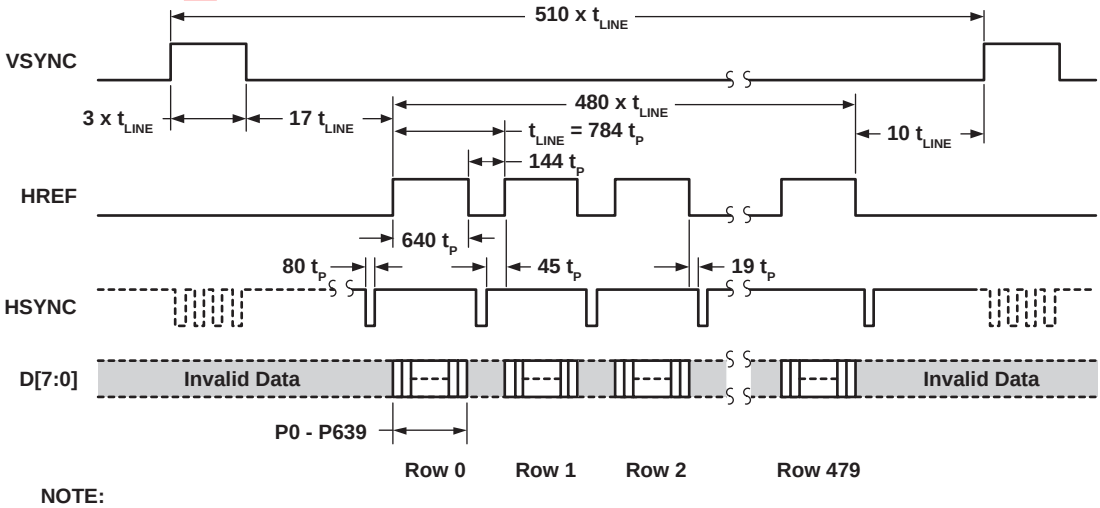


Figure 6 VGA Frame Timing



NOTE:
For Raw data, $t_P = t_{PCLK}$

For YUV/RGB, $t_P = 2 \times t_{PCLK}$

Figure 7 QVGA Frame Timing

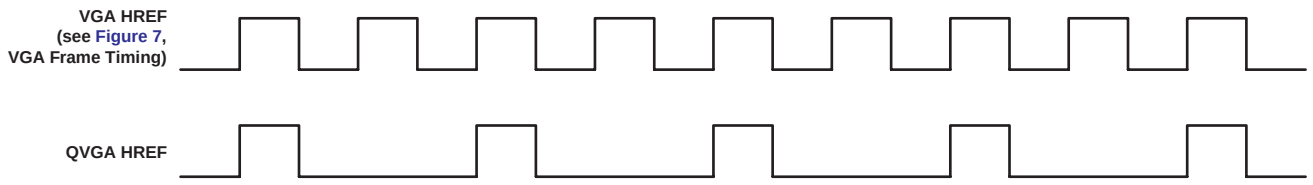


Figure 8 QQVGA Frame Timing

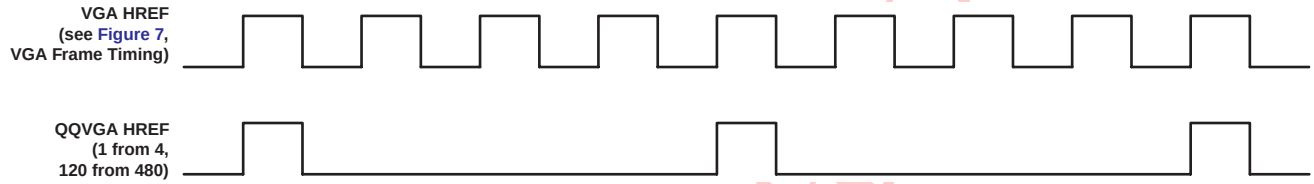


Figure 9 CIF Frame Timing

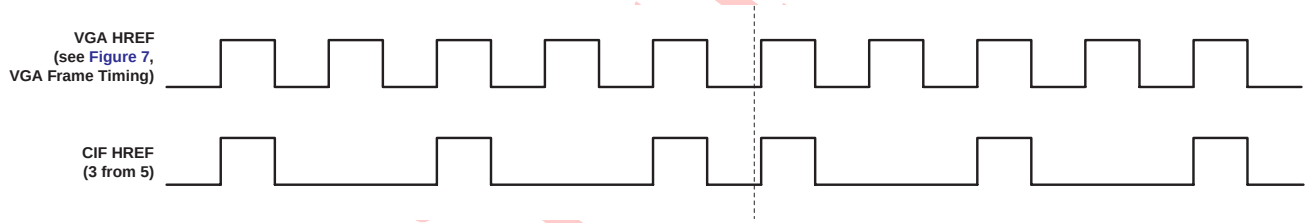


Figure 10 QCIF Frame Timing

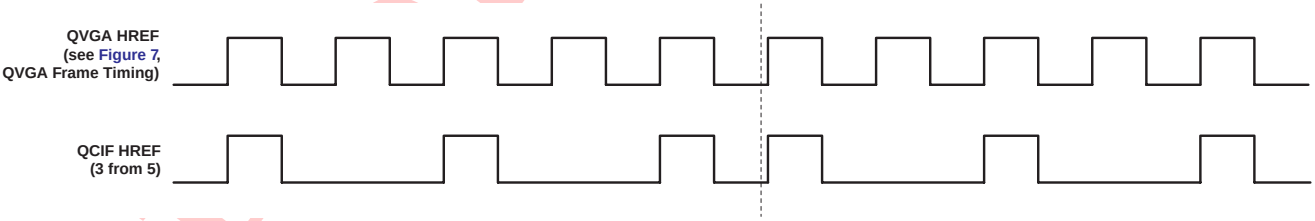


Figure 11 RGB 565 Output Timing Diagram

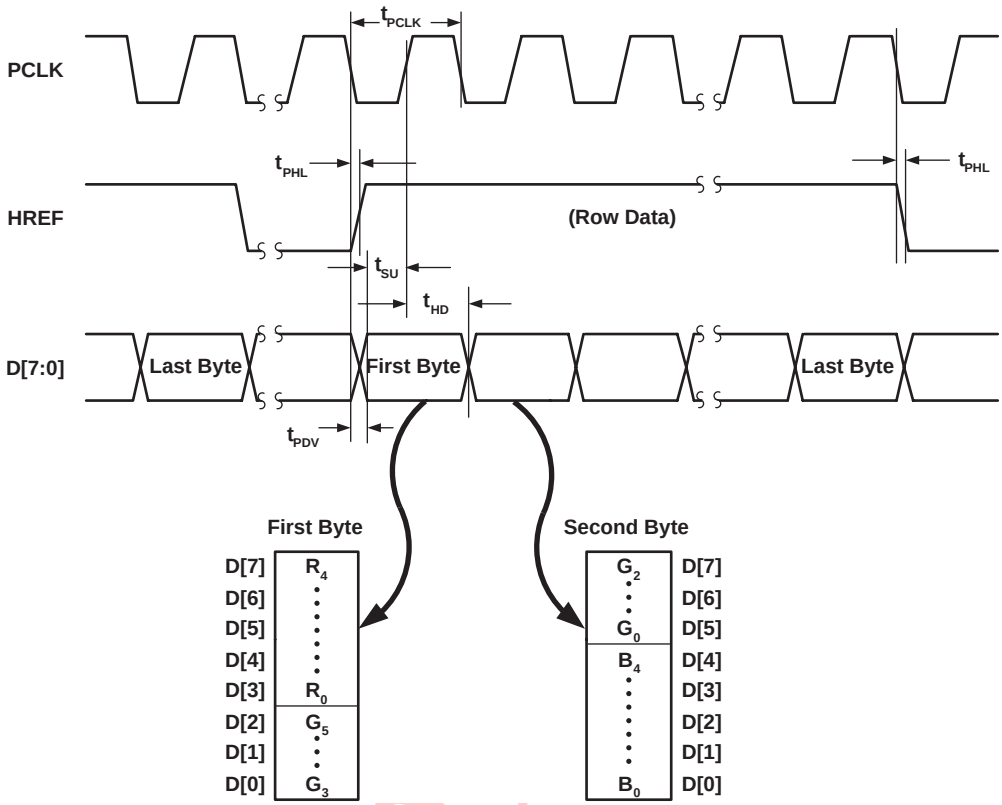
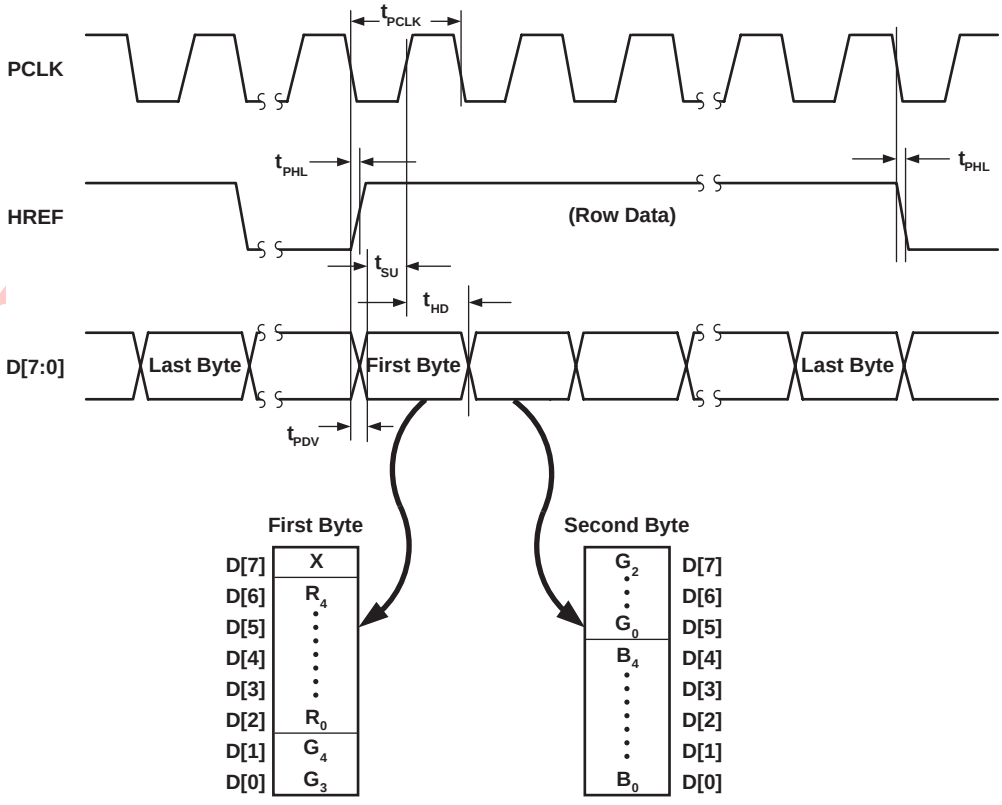


Figure 12 RGB 555 Output Timing Diagram



Register Set

Table 5 provides a list and description of the Device Control registers contained in the OV7670/OV7171. For all register Enable/Disable bits, ENABLE = 1 and DISABLE = 0. The device slave addresses are 42 for write and 43 for read.

Table 5 Device Control Register List

Address (Hex)	Register Name	Default (Hex)	R/W	Description
00	GAIN	00	RW	AGC – Gain control gain setting Bit[7:0]: AGC[7:0] (see VREF[7:6] (0x03) for AGC[9:8]) • Range: [00] to [FF]
01	BLUE	80	RW	AWB – Blue channel gain setting • Range: [00] to [FF]
02	RED	80	RW	AWB – Red channel gain setting • Range: [00] to [FF]
03	VREF	03	RW	Vertical Frame Control Bit[7:6]: AGC[9:8] (see GAIN[7:0] (0x00) for AGC[7:0]) Bit[5:4]: Reserved Bit[3:2]: VREF end low 2 bits (high 8 bits at VSTOP[7:0] Bit[1:0]: VREF start low 2 bits (high 8 bits at VSTRT[7:0]
04	COM1	00	RW	Common Control 1 Bit[7]: Reserved Bit[6]: CCIR656 format 0: Disable 1: Enable Bit[5:2]: Reserved Bit[1:0]: AEC low 2 LSB (see registers AECHH for AEC[15:10] and AECH for AEC[9:2])
05	BAVE	00	RW	U/B Average Level Automatically updated based on chip output format
06	GbAVE	00	RW	Y/Gb Average Level Automatically updated based on chip output format
07	AECHH	00	RW	Exposure Value - AEC MSB 5 bits Bit[7:6]: Reserved Bit[5:0]: AEC[15:10] (see registers AECH for AEC[9:2] and COM1 for AEC[1:0])
08	RAVE	00	RW	V/R Average Level Automatically updated based on chip output format
09	COM2	01	RW	Common Control 2 Bit[7:5]: Reserved Bit[4]: Soft sleep mode Bit[3:2]: Reserved Bit[1:0]: Output Drive Capability 00: 1x 01: 2x 10: 3x 11: 4x

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
0A	PID	76	R	Product ID Number MSB (Read only)
0B	VER	70	R	Product ID Number LSB (Read only)
0C	COM3	00	RW	Common Control 3 Bit[7]: Reserved Bit[6]: Output data MSB and LSB swap Bit[5]: Tri-state option for output clock at power-down period 0: Tri-state at this period 1: No tri-state at this period Bit[4]: Tri-state option for output data at power-down period 0: Tri-state at this period 1: No tri-state at this period Bit[3]: Scale enable 0: Disable 1: Enable - if set to a pre-defined format (see COM7[5:3]), then COM14[3] must be set to 1 for manual adjustment. Bit[2]: DCW enable 0: Disable 1: Enable - if set to a pre-defined format (see COM7[5:3]), then COM14[3] must be set to 1 for manual adjustment. Bit[1:0]: Reserved
0D	COM4	40	RW	Common Control 4 Bit[7:6]: Reserved Bit[5:4]: Average option (must be same value as COM17[7:6]) 00: Full window 01: 1/2 window 10: 1/4 window 11: 1/4 window Bit[3:0]: Reserved
0E	COM5	01	RW	Common Control 5 Bit[7:0]: Reserved
0F	COM6	43	RW	Common Control 6 Bit[7]: Output of optical black line option 0: Disable HREF at optical black 1: Enable HREF at optical black Bit[6]: BLC input selection 0: Use electrical black line as BLC signal 1: Use optical black line as BLC signal Bit[5]: Digital BLC enable Bit[4:2]: Reserved Bit[1]: Reset all timing when format changes Bit[0]: Reserved
10	AECH	40	RW	Exposure Value Bit[7:0]: AEC[9:2] (see registers AECHH for AEC[15:10] and COM1 for AEC[1:0])

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
11	CLKRC	80	RW	Internal Clock Bit[7]: Digital PLL option 0: Disable double clock option, meaning the maximum PCLK can be as high as half input clock 1: Enable double clock option, meaning the maximum PCLK can be as high as input clock Bit[6]: Use external clock directly (no clock pre-scale available) Bit[5:0]: Internal clock pre-scalar F(internal clock) = F(input clock)/(Bit[5:0]+1) • Range: [0 0000] to [1 1111]
12	COM7	00	RW	Common Control 7 Bit[7]: SCCB Register Reset 0: No change 1: Resets all registers to default values Bit[6]: Reserved Bit[5]: Output format - CIF selection Bit[4]: Output format - QVGA selection Bit[3]: Output format - QCIF selection Bit[2]: Output format - RGB selection (see below) Bit[1]: Color bar 0: Disable 1: Enable Bit[0]: Output format - Raw RGB (see below) YUV: COM7[2]=0, COM7[0]=0 RGB: COM7[2]=1, COM7[0]=0 Bayer RAW: COM7[2]=0, COM7[0]=1 Processed Bayer RAW: COM7[2]=1, COM7[0]=1
13	COM8	8F	RW	Common Control 8 Bit[7]: Enable fast AGC/AEC algorithm Bit[6]: AEC - Step size limit 0: Step size is limited to vertical blank 1: Unlimited step size Bit[5]: Banding filter ON/OFF - In order to turn ON the banding filter, BD50ST (0x9D) or BD60ST (0x9E) must be set to a non-zero value. 0: ON 1: OFF Bit[4:3]: Reserved Bit[2]: AGC Enable Bit[1]: AWB Enable Bit[0]: AEC Enable

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
14	COM9	4A	RW	Common Control 9 Bit[7]: Reserved Bit[6:4]: Automatic Gain Ceiling - maximum AGC value 000: 2x 001: 4x 010 8x 011: 16x 100: 32x 101 64x 110: 128x 111: Not allowed Bit[3:1]: Reserved Bit[0]: Freeze AGC/AEC
15	COM10	00	RW	Common Control 10 Bit[7]: Reserved Bit[6]: HREF changes to HSYNC Bit[5]: PCLK output option 0: Free running PCLK 1: PCLK does not toggle during horizontal blank Bit[4]: PCLK reverse Bit[3]: HREF reverse Bit[2]: VSYNC option 0: VSYNC changes on falling edge of PCLK 1: VSYNC changes on rising edge of PCLK Bit[1]: VSYNC negative Bit[0]: HSYNC negative
16	RSVD	XX	–	Reserved
17	HSTART	11	RW	Output Format - Horizontal Frame (HREF column) start high 8-bit (low 3 bits are at HREF[2:0])
18	HSTOP	61	RW	Output Format - Horizontal Frame (HREF column) end high 8-bit (low 3 bits are at HREF[5:3])
19	VSTRT	03	RW	Output Format - Vertical Frame (row) start high 8-bit (low 2 bits are at VREF[1:0])
1A	VSTOP	7B	RW	Output Format - Vertical Frame (row) end high 8-bit (low 2 bits are at VREF[3:2])
1B	PSHFT	00	RW	Data Format - Pixel Delay Select (delays timing of the D[7:0] data relative to HREF in pixel units) • Range: [00] (no delay) to [FF] (256 pixel delay which accounts for whole array)
1C	MIDH	7F	R	Manufacturer ID Byte – High (Read only = 0x7F)
1D	MIDL	A2	R	Manufacturer ID Byte – Low (Read only = 0xA2)

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
1E	MVFP	00	RW	Mirror/VFlip Enable Bit[7:6]: Reserved Bit[5]: Mirror 0: Normal image 1: Mirror image Bit[4]: VFlip enable 0: Normal image 1: Vertically flip image Bit[3]: Reserved Bit[2]: Black sun enable Bit[1:0]: Reserved
1F	LAEC	00	RW	Reserved
20	ADCCTR0	04	RW	ADC Control Bit[7:4]: Reserved Bit[3]: ADC range adjustment 0: 1x range 1: 1.5x range Bit[2:0]: ADC reference adjustment 000: 0.8x 100: 1x 111: 1.2x
21	ADCCTR1	02	RW	Bit[7:0]: Reserved
22	ADCCTR2	01	RW	Bit[7:0]: Reserved
23	ADCCTR3	80	RW	Bit[7:0]: Reserved
24	AEW	75	RW	AGC/AEC - Stable Operating Region (Upper Limit)
25	AEB	63	RW	AGC/AEC - Stable Operating Region (Lower Limit)
26	VPT	D4	RW	AGC/AEC Fast Mode Operating Region Bit[7:4]: High nibble of upper limit of fast mode control zone Bit[3:0]: High nibble of lower limit of fast mode control zone
27	BBIAS	80	RW	B Channel Signal Output Bias (effective only when COM6[3] = 1) Bit[7]: Bias adjustment sign 0: Add bias 1: Subtract bias Bit[6:0]: Bias value of 10-bit range
28	GbBIAS	80	RW	Gb Channel Signal Output Bias (effective only when COM6[3] = 1) Bit[7]: Bias adjustment sign 0: Add bias 1: Subtract bias Bit[6:0]: Bias value of 10-bit range
29	RSVD	XX	–	Reserved
2A	EXHCH	00	RW	Dummy Pixel Insert MSB Bit[7:4]: 4 MSB for dummy pixel insert in horizontal direction Bit[3:2]: HSYNC falling edge delay 2 MSB Bit[1:0]: HSYNC rising edge delay 2 MSB

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
2B	EXHCL	00	RW	Dummy Pixel Insert LSB 8 LSB for dummy pixel insert in horizontal direction
2C	RBIAS	80	RW	R Channel Signal Output Bias (effective only when COM6[3] = 1) Bit[7]: Bias adjustment sign 0: Add bias 1: Subtract bias Bit[6:0]: Bias value of 10-bit range
2D	ADVFL	00	RW	LSB of insert dummy lines in vertical direction (1 bit equals 1 line)
2E	ADVFH	00	RW	MSB of insert dummy lines in vertical direction
2F	YAVE	00	RW	Y/G Channel Average Value
30	HSYST	08	RW	HSYNC Rising Edge Delay (low 8 bits)
31	HSYEN	30	RW	HSYNC Falling Edge Delay (low 8 bits)
32	HREF	80	RW	HREF Control Bit[7:6]: HREF edge offset to data output Bit[5:3]: HREF end 3 LSB (high 8 MSB at register HSTOP) Bit[2:0]: HREF start 3 LSB (high 8 MSB at register HSTART)
33	CHLF	08	RW	Array Current Control Bit[7:0]: Reserved
34	ARBLM	03	RW	Array Reference Control Bit[7:0]: Reserved
35-36	RSVD	XX	–	Reserved
37	ADC	04	RW	ADC Control Bit[7:0]: Reserved
38	ACOM	12	RW	ADC and Analog Common Mode Control Bit[7:0]: Reserved
39	OFON	00	RW	ADC Offset Control Bit[7:0]: Reserved
3A	TSLB	0C	RW	Line Buffer Test Option Bit[7:6]: Reserved Bit[5]: Negative image enable 0: Normal image 1: Negative image Bit[4]: UV output value 0: Use normal UV output 1: Use fixed UV value set in registers MANU and MANV as UV output instead of chip output Bit[3]: Output sequence (use with register COM13[1] (0x3D)) TSLB[3], COM13[1]: 00: Y U Y V 01: Y V Y U 10: U Y V Y 11: V Y U Y Bit[2:0]: Reserved

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
3B	COM11	00	RW	Common Control 11 Bit[7]: Night mode 0: Night mode disable 1: Night mode enable - The frame rate is reduced automatically while the minimum frame rate is limited by COM11[6:5]. Also, ADVFH and ADVFL will be automatically updated. Bit[6:5]: Minimum frame rate of night mode 00: Same as normal mode frame rate 01: 1/2 of normal mode frame rate 10: 1/4 of normal mode frame rate 11: 1/8 of normal mode frame rate Bit[4]: D56_Auto 0: Disable 50/60 Hz auto detection 1: Enable 50/60 Hz auto detection Bit[3]: Banding filter value select (effective only when COM11[4] = 0) 0: Select BD60ST[7:0] (0x9E) as Banding Filter Value 1: Select BD50ST[7:0] (0x9D) as Banding Filter Value Bit[2]: Reserved Bit[1]: Exposure timing can be less than limit of banding filter when light is too strong Bit[0]: Reserved
3C	COM12	40	RW	Common Control 12 Bit[7]: HREF option 0: No HREF when VSYNC is low 1: Always has HREF Bit[6:0]: Reserved
3D	COM13	99	RW	Common Control 13 Bit[7]: Gamma enable Bit[6]: UV saturation level - UV auto adjustment. Result is saved in register SATCTR[3:0] (0xC9) Bit[5:2]: Reserved Bit[1]: UV swap (use with register TSLB[3] (0x3A)) TSLB[3], COM13[1]: 00: Y U Y V 01: Y V Y U 10: U Y V Y 11: V Y U Y Bit[0]: Reserved

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
3E	COM14	0E	RW	Common Control 14 Bit[7:5]: Reserved Bit[4]: DCW and scaling PCLK enable 0: Normal PCLK 1: DCW and scaling PCLK, controlled by register COM14[2:0] and SCALING_PCLK_DIV[3:0] (0x73)) Bit[3]: Manual scaling enable for pre-defined resolution modes such as CIF, QCIF, and QVGA 0: Scaling parameter cannot be adjusted manually 1: Scaling parameter can be adjusted manually Bit[2:0]: PCLK divider (only when COM14[4] = 1) 000: Divided by 1 001: Divided by 2 010 Divided by 4 011: Divided by 8 100: Divided by 16 101~111: Not allowed
3F	EDGE	88	RW	Edge Enhancement Adjustment Bit[7:5]: Reserved Bit[4:0]: Edge enhancement factor
40	COM15	C0	RW	Common Control 15 Bit[7:6]: Data format - output full range enable 0x: Output range: [10] to [F0] 10: Output range: [01] to [FE] 11: Output range: [00] to [FF] Bit[5:4]: RGB 555/565 option (must set COM7[2] = 1 and COM7[0] = 0) x0: Normal RGB output 01: RGB 565 11: RGB 555 Bit[3:0]: Reserved

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
41	COM16	10	RW	Common Control 16 Bit[7:6]: Reserved Bit[5]: Enable edge enhancement threshold auto-adjustment for YUV output (result is saved in register EDGE[4:0] (0x3F) and range is controlled by registers REG75[4:0] (0x75) and REG76[4:0] (0x76)) 0: Disable 1: Enable Bit[4]: De-noise threshold auto-adjustment (result is saved in register DNSTH (0x4C) and range is controlled by register REG77[7:0] (0x77)) 0: Disable 1: Enable Bit[3]: AWB gain enable Bit[2]: Reserved Bit[1]: Color matrix coefficient double option 0: Original matrix 1: Double of original matrix Bit[0]: Reserved
42	COM17	08	RW	Common Control 17 Bit[7:6]: AEC window must be the same value as COM4[5:4]) 00: Normal 01: 1/2 10: 1/4 11: 1/4 Bit[5:4]: Reserved Bit[3]: DSP color bar enable 0: Disable 1: Enable Bit[2:0]: Reserved
43	AWBC1	14	RW	Reserved
44	AWBC2	F0	RW	Reserved
45	AWBC3	45	RW	Reserved
46	AWBC4	61	RW	Reserved
47	AWBC5	51	RW	Reserved
48	AWBC6	79	RW	Reserved
49-4A	RSVD	XX	–	Reserved
4B	REG4B	00	RW	Register 4B Bit[7:1]: Reserved Bit[0]: UV average enable
4C	DNSTH	00	RW	De-noise Threshold
4D-4E	RSVD	XX	–	Reserved
4F	MTX1	40	RW	Matrix Coefficient 1
50	MTX2	34	RW	Matrix Coefficient 2

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
51	MTX3	0C	RW	Matrix Coefficient 3
52	MTX4	17	RW	Matrix Coefficient 4
53	MTX5	29	RW	Matrix Coefficient 5
54	MTX6	40	RW	Matrix Coefficient 6
55	BRIGHT	00	RW	Brightness Control
56	CONTRAS	40	RW	Contrast Control
57	CONTRAS-CENTER	80	RW	Contrast Center
58	MTXS	1E	RW	Matrix Coefficient Sign for coefficient 5 to 0 Bit[7]: Auto contrast center enable 0: Disable, center is set by register CONTRAS-CENTER (0x57) 1: Enable, register CONTRAS-CENTER is updated automatically Bit[6]: Reserved Bit[5:0]: Matrix coefficient sign 0: Plus 1: Minus
59-61	RSVD	XX	–	AWB Control
62	LCC1	00	RW	Lens Correction Option 1
63	LCC2	00	RW	Lens Correction Option 2
64	LCC3	10	RW	Lens Correction Option 3
65	LCC4	80	RW	Lens Correction Option 4
66	LCC5	00	RW	Lens Correction Control Bit[7:3]: Reserved Bit[2]: Lens correction control select Bit[1]: Reserved Bit[0]: Lens correction enable
67	MANU	80	RW	Manual U Value (effective only when register TSLB[4] is high)
68	MANV	80	RW	Manual V Value (effective only when register TSLB[4] is high)

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
69	GFIX	00	RW	Fix Gain Control Bit[7:6]: Fix gain for Gr channel 00: 1x 01: 1.25x 10: 1.5x 11: 1.75x Bit[5:4]: Fix gain for Gb channel 00: 1x 01: 1.25x 10: 1.5x 11: 1.75x Bit[3:2]: Fix gain for R channel 00: 1x 01: 1.25x 10: 1.5x 11: 1.75x Bit[1:0]: Fix gain for B channel 00: 1x 01: 1.25x 10: 1.5x 11: 1.75x
6A	GGAIN	00	RW	G Channel AWB Gain
6B	DBLV	3A	RW	Bit[7:6]: PLL control 00: Bypass PLL 01: Input clock x4 10: Input clock x8 11: Input clock x16 Bit[5]: Reserved Bit[4]: Regulator control 0: Enable internal regulator 1: Bypass internal regulator Bit[3:0]: Clock divider control for DSP scale control (valid only when COM14[3] = 1)
6C	AWBCTR3	02	RW	AWB Control 3
6D	AWBCTR2	55	RW	AWB Control 2
6E	AWBCTR1	00	RW	AWB Control 1
6F	AWBCTR0	9A	RW	AWB Control 0
70	SCALING_XSC	4A	RW	Bit[7]: Test_pattern[0] - works with test_pattern[1] test_pattern (SCALING_XSC[7], SCALING_YSC[7]): 00: No test output 01: Shifting "1" 10: 8-bar color bar 11: Fade to gray color bar Bit[6:0]: Horizontal scale factor

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
71	SCALING_YSC	35	RW	Bit[7]: Test_pattern[1] - works with test_pattern[0] test_pattern (SCALING_XSC[7], SCALING_YSC[7]):: 00: No test output 01: Shifting "1" 10: 8-bar color bar 11: Fade to gray color bar Bit[6:0]: Vertical scale factor
72	SCALING_DCWCTR	11	RW	DCW Control Bit[7:0]: DCW control parameter
73	SCALING_PCLK_DIV	00	RW	Bit[7:4]: Reserved Bit[3:0]: Clock divider control for DSP scale control (valid only when COM14[3] = 1). Should change with COM14[2:0]. 0000: Divided by 1 0001: Divided by 2 0010: Divided by 4 0011: Divided by 8 0100: Divided by 16 0101~1111: Not allowed
74	REG74	00	RW	Bit[7:5]: Reserved Bit[4]: DG_Manu 0: Digital gain control by VREF[7:6] 1: Digital gain control by REG74[1:0] Bit[3:2]: Reserved Bit[1:0]: Digital gain manual control 00: Bypass 01: 1x 10: 2x 11: 4x
75	REG75	0F	RW	Register 75 Bit[7:5]: Reserved Bit[4:0]: Edge enhancement lower limit
76	REG76	01	RW	Register 76 Bit[7]: Reserved Bit[6]: White pixel correction enable 0: Disable 1: Enable Bit[5]: Black pixel correction enable 0: Disable 1: Enable Bit[4:0]: Edge enhancement higher limit
77	REG77	10	RW	Register 77 Bit[7:0]: Offset, de-noise range control
78-79	RSVD	XX	–	Reserved
7A	GAM1	02	RW	Gamma Curve 1st Segment Input End Point 0x010 Output Value
7B	GAM2	07	RW	Gamma Curve 2nd Segment Input End Point 0x020 Output Value
7C	GAM3	1F	RW	Gamma Curve 3rd Segment Input End Point 0x040 Output Value

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
7D	GAM4	49	RW	Gamma Curve 4th Segment Input End Point 0x080 Output Value
7E	GAM5	5A	RW	Gamma Curve 5th Segment Input End Point 0x0A0 Output Value
7F	GAM6	6A	RW	Gamma Curve 6th Segment Input End Point 0x0C0 Output Value
80	GAM7	79	RW	Gamma Curve 7th Segment Input End Point 0x0E0 Output Value
89	GAM8	87	RW	Gamma Curve 8th Segment Input End Point 0x100 Output Value
89	GAM9	94	RW	Gamma Curve 9th Segment Input End Point 0x120 Output Value
89	GAM10	9F	RW	Gamma Curve 10th Segment Input End Point 0x140 Output Value
89	GAM11	AF	RW	Gamma Curve 11th Segment Input End Point 0x180 Output Value
86	GAM12	BB	RW	Gamma Curve 12th Segment Input End Point 0x1C0 Output Value
87	GAM13	CF	RW	Gamma Curve 13th Segment Input End Point 0x240 Output Value
88	GAM14	EE	RW	Gamma Curve 14th Segment Input End Point 0x2C0 Output Value
89	GAM15	EE	RW	Gamma Curve 15th Segment Input End Point 0x340 Output Value
8A-91	RSVD	XX	–	Reserved
92	DM_LNL	00	RW	Dummy Line low 8 bits
93	DM_LNH	00	RW	Dummy Line high 8 bits
94	LCC6	50	RW	Lens Correction Option 6 (effective only when LCC5[2] is high)
95	LCC7	50	RW	Lens Correction Option 7 (effective only when LCC5[2] is high)
96-9C	RSVD	XX	–	Reserved
9D	BD50ST	99	RW	50 Hz Banding Filter Value (effective only when COM8[5] is high and COM11[3] is high)
9E	BD60ST	7F	RW	60 Hz Banding Filter Value (effective only when COM8[5] is high and COM11[3] is low)
9F-AB		XX	–	Histogram-based AEC/AGC Control
AC	STR-OPT	00	RW	Register AC Bit[7]: Strobe enable Bit[6]: R / G / B gain controlled by STR_R (0xAD) / STR_G (0xAE) / STR_B (0xAF) for LED output frame Bit[5:4]: Xenon mode option 00: 1 line 01: 2 lines 10: 3 lines 11: 4 lines Bit[3:2]: Reserved Bit[1:0]: Mode select 00: Xenon 01: LED 1&2 1x: LED 3
AD	STR_R	80	RW	R Gain for LED Output Frame
AE	STR_G	80	RW	G Gain for LED Output Frame
AF	STR_B	80	RW	B Gain for LED Output Frame

Table 5 Device Control Register List (Continued)

Address (Hex)	Register Name	Default (Hex)	R/W	Description
B0-B2	RSVD	XX	–	Reserved
B3	THL_ST	80	RW	Digital BLC Target
B4	RSVD	XX	–	Reserved
B5	THL_DLT	04	RW	Digital BLC Stable Range
B6-BD	RSVD	XX	–	Reserved
BE	AD-CHB	00	RW	Bit[7]: Reserved Bit[6]: Sign bit Bit[5:0]: ADC offset value
BF	AD-CHR	00	RW	Bit[7]: Reserved Bit[6]: Sign bit Bit[5:0]: ADC offset value
C0	AD-CHGb	00	RW	Bit[7]: Reserved Bit[6]: Sign bit Bit[5:0]: ADC offset value
C1	AD-CHGr	00	RW	Bit[7]: Reserved Bit[6]: Sign bit Bit[5:0]: ADC offset value
C2-C8	RSVD	XX	–	Reserved
C9	SATCTR	C0	RW	Saturation Control Bit[7:4]: UV saturation control min Bit[3:0]: UV saturation control result
NOTE: All other registers are factory-reserved. Please contact OmniVision Technologies for reference register settings.				

Package Specifications

The OV7670/OV7171 uses a 24-ball Chip Scale Package 2 (CSP2). Refer to Figure 13 for package information, Table 6 for package dimensions and Figure 14 for the array center on the chip.

Note: For OVT devices that are lead-free, all part marking letters are lower case. Underlining the last digit of the lot number indicates CSP2 is used.

Figure 13 OV7670/OV7171 Package Specifications

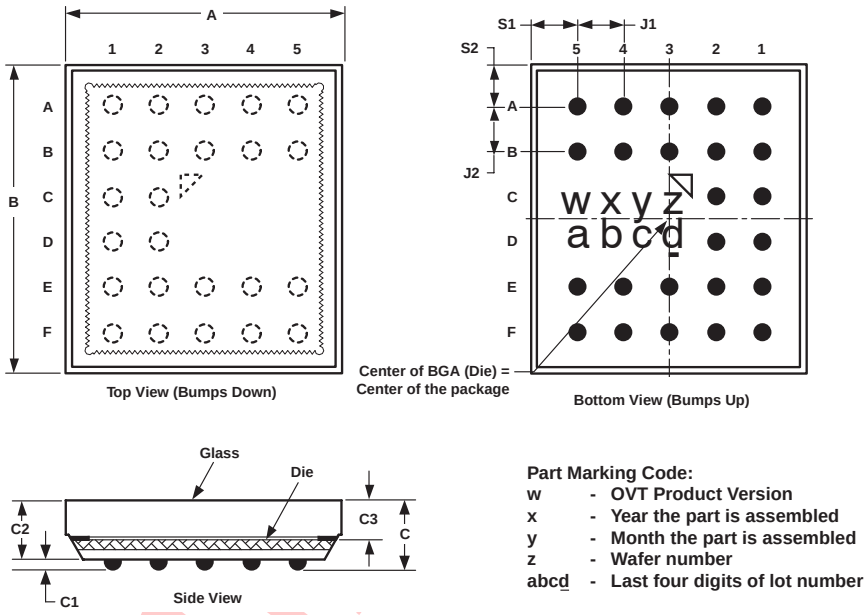
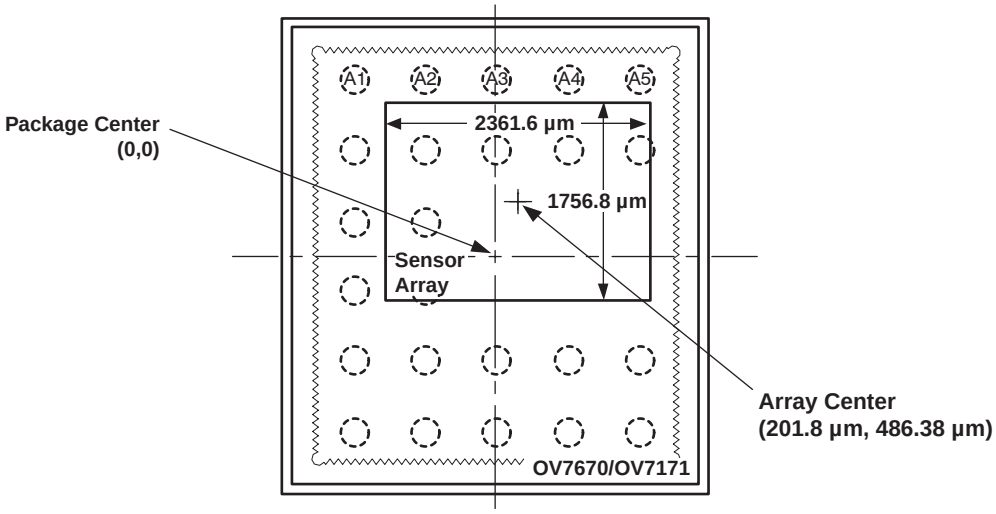


Table 6 OV7670/OV7171 Package Dimensions

Parameter	Symbol	Minimum	Nominal	Maximum	Unit
Package Body Dimension X	A	3760	3785	3810	µm
Package Body Dimension Y	B	4210	4235	4260	µm
Package Height	C	825	885	945	µm
Ball Height	C1	130	160	190	µm
Package Body Thickness	C2	680	725	770	µm
Thickness of Glass Surface to Wafer	C3	425	445	465	µm
Ball Diameter	D	270	300	330	µm
Total Pin Count	N		24		
Pin Count X-axis	N1		5		
Pin Count Y-axis	N2		6		
Pins Pitch X-axis	J1		620		µm
Pins Pitch Y-axis	J2		620		µm
Edge-to-Pin Center Distance Analog X	S1	623	653	683	µm
Edge-to-Pin Center Distance Analog Y	S2	538	568	598	µm

Sensor Array Center

Figure 14 OV7670/OV7171 Sensor Array Center



TOP VIEW

NOTES: 1. This drawing is not to scale and is for reference only.

2. As most optical assemblies invert and mirror the image, the chip is typically mounted with pins A1 to A5 oriented down on the PCB.

IR Reflow Ramp Rate Requirements

OV7670/OV7171 Lead-Free Packaged Devices

Note: For OVT devices that are lead-free, all part marking letters are lower case

Figure 15 IR Reflow Ramp Rate Requirements

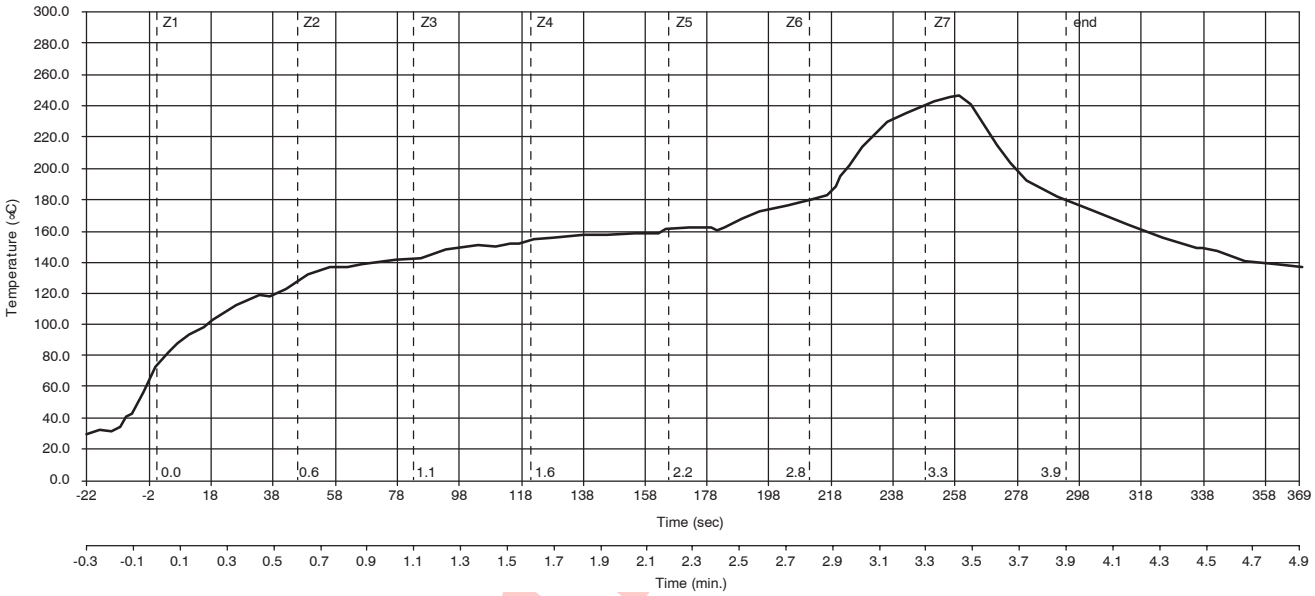


Table 7 Reflow Conditions

Condition	Exposure
Average Ramp-up Rate (30°C to 217°C)	Less than 3°C per second
> 100°C	Between 330 - 600 seconds
> 150°C	At least 210 seconds
> 217°C	At least 30 seconds (30 ~ 120 seconds)
Peak Temperature	245°C
Cool-down Rate (Peak to 50°C)	Less than 6°C per second
Time from 30°C to 255°C	No greater than 390 seconds

Note:

- *All information shown herein is current as of the revision and publication date. Please refer to the OmniVision web site (http://www.ovt.com) to obtain the current versions of all documentation.*

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For further information, please feel free to contact OmniVision at info@ovt.com.

OmniVision Technologies, Inc.
1341 Orleans Drive
Sunnyvale, CA USA
(408) 542-3000

REVISION CHANGE LIST

Document Title: OV7670 Datasheet **Version:** 1.0

DESCRIPTION OF CHANGES

Initial Release

REVISION CHANGE LIST

Document Title: OV7670 Datasheet **Version:** 1.01

DESCRIPTION OF CHANGES

The following changes were made to version 1.0:

- Under LED and Strobe Flash Control Output section on page 3, changed text from “Refer to the OmniVision Technologies LED Strobe Support document” to “The OV7670 has a Strobe mode that allows it to work with an external flash and LED”