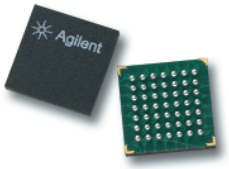
Agilent HDCP-2010 Image Processor

Data Sheet



Description

The HDCP-2010 provides a complete image-processing pipeline for the Agilent family of CMOS image sensors. This part transforms the raw output data from the CMOS sensor into final images using a high performance image processor. Complete sensor control is performed by the HDCP-2010, including auto-exposure, illumination compensation, and auto white balance. Data output is 4:4:4 or 4:2:2 YUV or compressed JPEG via parallel or serial interface.

The HDCP-2010 enables imaging in many different types of devices, such as handheld computers, cellular phones, and notebook computers. The chip-set combination of the HDCP-2010 and a HDCS CMOS image sensor delivers to another device a complete image in JPEG format, ready for storage or transmission. By producing a high-quality finished picture, the host system is relieved of all image-processing, thus allowing for the incorporation of imaging technology in a wide range of products.

For standalone imaging, the HDCP-2010 can be coupled with a low-cost micro-controller to provide a complete camera solution. The HDCP-2010 contains the entire image processing system, while the micro-controller controls the image storage, user interface and power management. The simple system designs enabled by the HDCP-2010 will bring imaging to new product types and markets.

Features

- **High quality image processor—sophisticated imaging algorithms**
- **Fully processed image output—Direct JPEG or YUV format**
- **Auto-exposure**
- **Auto white balance**
- **Pixel correction**
- **Versatile image pipeline—fully programmable gamma correction and color balance matrices**
- **Demosaic**
- **Color space conversion**
- **Pixel processing rate—12 million pixels/second**
- **Reference design and evaluation kit available—includes USB VGA camera, PC drivers/software, and schematics**

Sensors Supported

- **HDCS-1020 (CIF)**
- **HDCS-2020 (VGA)**

Applications

- **PDAs**
- **Notebook computers**
- **Video phones**
- **Low-cost digital still cameras**

Agilent Technologies

Package Ball Layout

The HDCP-2010 uses a 49 ball ChipArray™.

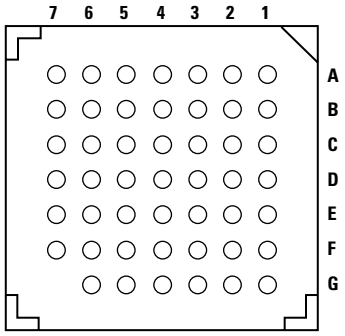


Figure 1. Ball Grid Array (bottom view).

Table 1. Package Pin Assignment and Function.

Pin	Name	Type	Pin	Name	Type
A1	IPC_TWIN_sdata	Input/output	D5	Gnd	Ground
A2	Mode_select[0]	Input	D6	GPIO_0	Input/output
A3	IPC_TWIN_sclk	Input	D7	Vdd_3.3V	Power
A4	Sensor_clock	Output	E1	End_of_frame	Output
A5	Sensor_nRow	Input	E2	End_of_line	Output
A6	Sensor_data_ready	Input	E3	Data_ready	Output
A7	Sensor_nReset	Output	E4	Data_output[0]	Output
B1	Mode_select[1]	Input	E5	Sensor_data[0]	Input
B2	Mode_select[2]	Input	E6	Sensor_data[1]	Input
B3	Reserve/NO CONNECT	Output	E7	Sensor_data[3]	Input
B4	GPIO_1	Input/output	F1	Data_output[3]	Output
B5	nPOR	Input	F2	Data_output[1]	Output
B6	Sensor_TWIN_data	Input/output	F3	Data_output[2]	Output
B7	Sensor_nFrame	Input	F4	Sensor_data[2]	Input
C1	VddA_1.8V	Power	F5	Sensor_data[4]	Input
C2	Vdd_1.8V	Power	F6	Sensor_data[6]	Input
C3	Crystal_output	output	F7	Sensor_data[5]	Input
C4	Gnd	Ground	G1	Data_output[7]	Output
C5	Gnd	Ground	G2	Data_output[5]	Output
C6	Vdd_1.8V	Power	G3	Data_output[4]	Output
C7	Sensor_TWIN_clock	Output	G4	Data_output[6]	Output
D1	Gnd	Ground	G5	Sensor_data[8]	Input
D2	Crystal_input	Input	G6	Sensor_data[9]	Input
D3	Vdd_3.3V	Power	G7	Sensor_data[7]	Input
D4	Gnd	Ground			

Pin Descriptions

Power and Ground

Table 2. Power and Ground Pin Numbers and Descriptions.

Pin Name	Pin	Type	Function
Vdd_1.8V	C2, C6	Power	Core Vdd input – 1.8V nominal
VddA_1.8V	C1	Power	Analog Vdd input – 1.8V nominal
Vdd_3.3V	D3, D7	Power	Pad Vdd input – 3.3V nominal
Gnd	C4, C5, D1, D4, D5	Ground	Ground connection

Miscellaneous

Table 3. Mode Select, Clock, General Purpose Input/Output and Reset Pin Numbers and Descriptions.

Pin Name	Pin	Type	Function
Mode_select[0] Mode_select[1] Mode_select[2]	A2 B1 B2	Input Input Input	Determine clock mode and place HDCP-2010 in suspend/low power mode. See Table 3.
Crystal_output	C3	Input/output	16 MHz crystal output in **normal mode**.
Crystal_input	D2	Input	16 MHz crystal or external clock connection in **normal mode**. Connect to the same clock (48 MHz) signal as Crystal_output when operating in **external mode**.
GPIO_0	D6	Input/output	General-purpose input/output connection. Controlled through GPIO register.
GPIO_1	B4	Input/output	General-purpose input/output connection. Controlled through GPIO register.
nPOR	B5	Input	Active low power on reset connection (hold for 100 msec during power on).

Table 4. Clocking and Suspend/Low Power Modes.

		Input Logic Level		
Mode	**Description**	**Mode_select[2]**	**Mode_select[1]**	**Mode_select[0]**
Normal	Use crystal/external clock plus internal PLL	0	0	0
External	Use external clock and bypass internal PLL	0	1	1
Tri-state	Tri-state all pads	1	1	0

Two Wire Serial Interface

Table 5. Two Wire Serial Interface (TWIN) Pin Numbers and Descriptions.

Pin Name	Pin	Type	Function
IPC_TWIN_sclk	A3	Input	Receive serial data transfer synchronization signal (SCLK) from a master device.
IPC_TWIN_sdata	A1	Input/output	Send/receive serial data signal (SDATA).

Pin Descriptions, continued

HDCP-2010 Image Data Output

Table 6. Image Data Output Pin Numbers and Descriptions.

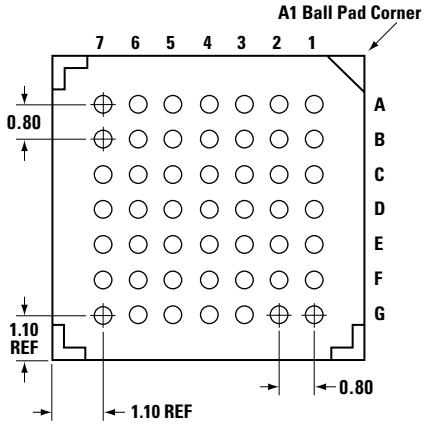
Pin Name	Pin	Type	Function
Data_ready	E3	Output	Transmit Data_ready signal when in **parallel** output mode. In **serial** output mode, Data_ready provides a serial synchronization signal.
End_of_line	E2	Output	Transmit End_of_line signal indicating that an image row has been transmitted when in **parallel** mode. In **serial** mode, End_of_line signals data valid.
End_of_frame	E1	Output	Transmit End_of_frame signal indicating last byte of frame and between frame states in both **parallel** and **serial** modes.
Data_output[0]	E4	Output	Output 8-bit parallel data in **parallel** mode. In **serial mode**, Data_output[7] transmits serialized data stream.
Data_output[1]	F2	Output	
Data_output[2]	F3	Output	
Data_output[3]	F1	Output	
Data_output[4]	G3	Output	
Data_output[5]	G2	Output	
Data_output[6]	G4	Output	
Data_output[7]	G1	Output	

Agilent CMOS Sensor Interface

Table 7. Image Sensor Interface Pin Numbers and Descriptions.

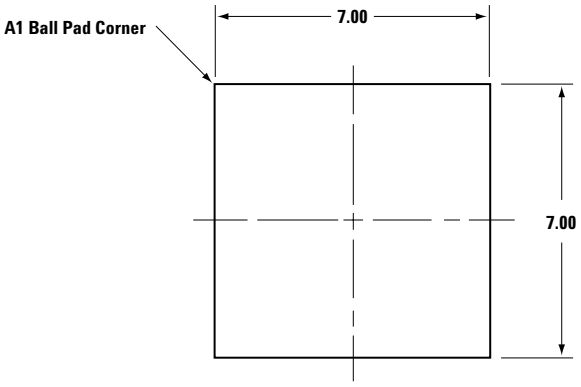
Pin Name	Pin	Type	Function
Sensor_clock	A4	Output	Provide system clock signal to image sensor.
Sensor_nReset	A7	Output	Transmit initialization signal to image sensor.
Sensor_TWIN_clock	C7	Output	Transmit serial data transfer synchronization signal.
Sensor_TWIN_data	B6	Input/output	Serial data transmission. This line is used to configure and monitor the sensor.
Sensor_data_ready	A6	Input	Receive data ready signal from image sensor.
Sensor_nRow	A5	Input	Receive signal indicating that an image row has been transmitted.
Sensor_nFrame	B7	Input	Receive signal indicating that an entire image frame has been transmitted.
Sensor_data[0]	E5	Input	Receive parallel digitized pixel data from the image sensor.
Sensor_data[1]	E6	Input	
Sensor_data[2]	F4	Input	
Sensor_data[3]	E7	Input	
Sensor_data[4]	F5	Input	
Sensor_data[5]	F7	Input	
Sensor_data[6]	F6	Input	
Sensor_data[7]	G7	Input	
Sensor_data[8]	G5	Input	
Sensor_data[9]	G6	Input	

Title????

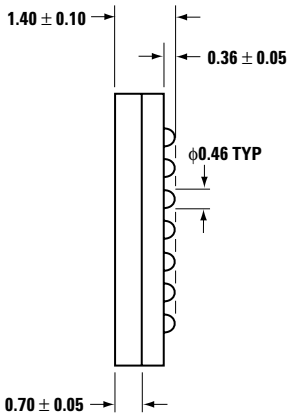


Bottom View: 49 solder balls

Package Dimensions



Top View



Side View

System Overview

The HDCP-2010 provides a complete image processing system (Figure 2). In addition to a configurable image processing block, the HDCP-2010 includes an image sensor control interface, a JPEG image compression procedure, a parallel or serial interface, two general purpose input/output pins and a two wire serial control interface.

Image Processor

The image processor block takes raw data from the CMOS image sensor and outputs image frames ready for JPEG compression. Figure 3 outlines the image processing procedures and lists configuration options. Auto-exposure includes automatic 50 Hz or 60 Hz flicker reduction. Data output from this block is 4:4:4 or 4:2:2 YUV format.

JPEG Image Compressor

This block is bypassed if YUV data is required. Using internally stored quantization and Huffman code tables, the JPEG function compresses and outputs processed image data. To reduce data transmission, no JPEG header is output with the compressed image data so receiving devices must maintain a copy of the header information. The JPEG header file is available at no charge.
(See www.agilent.semiconductor.com)
The HDCP-2010 can bypass the JPEG compression and output YUV data.

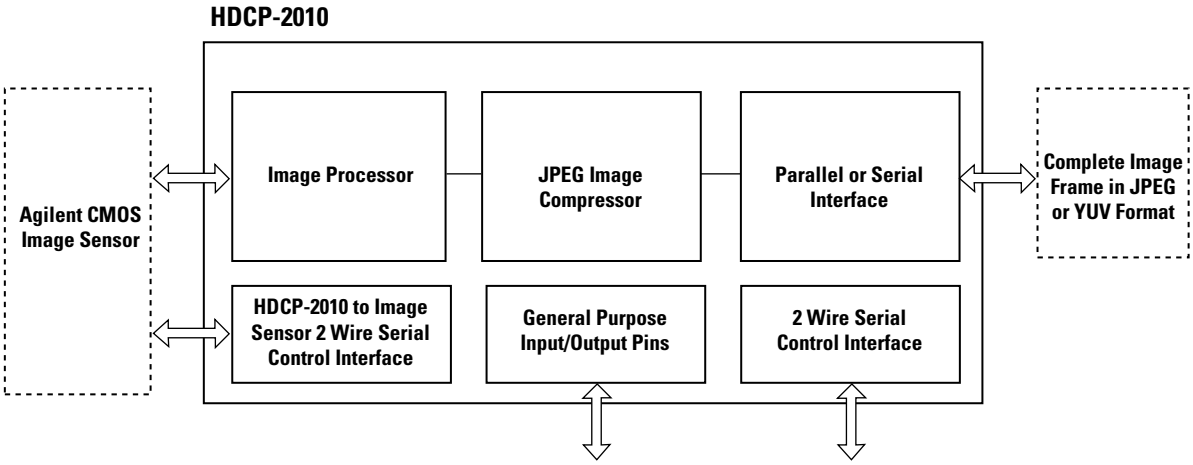


Figure 2. The HDCP-2010's Primary Functional Blocks.

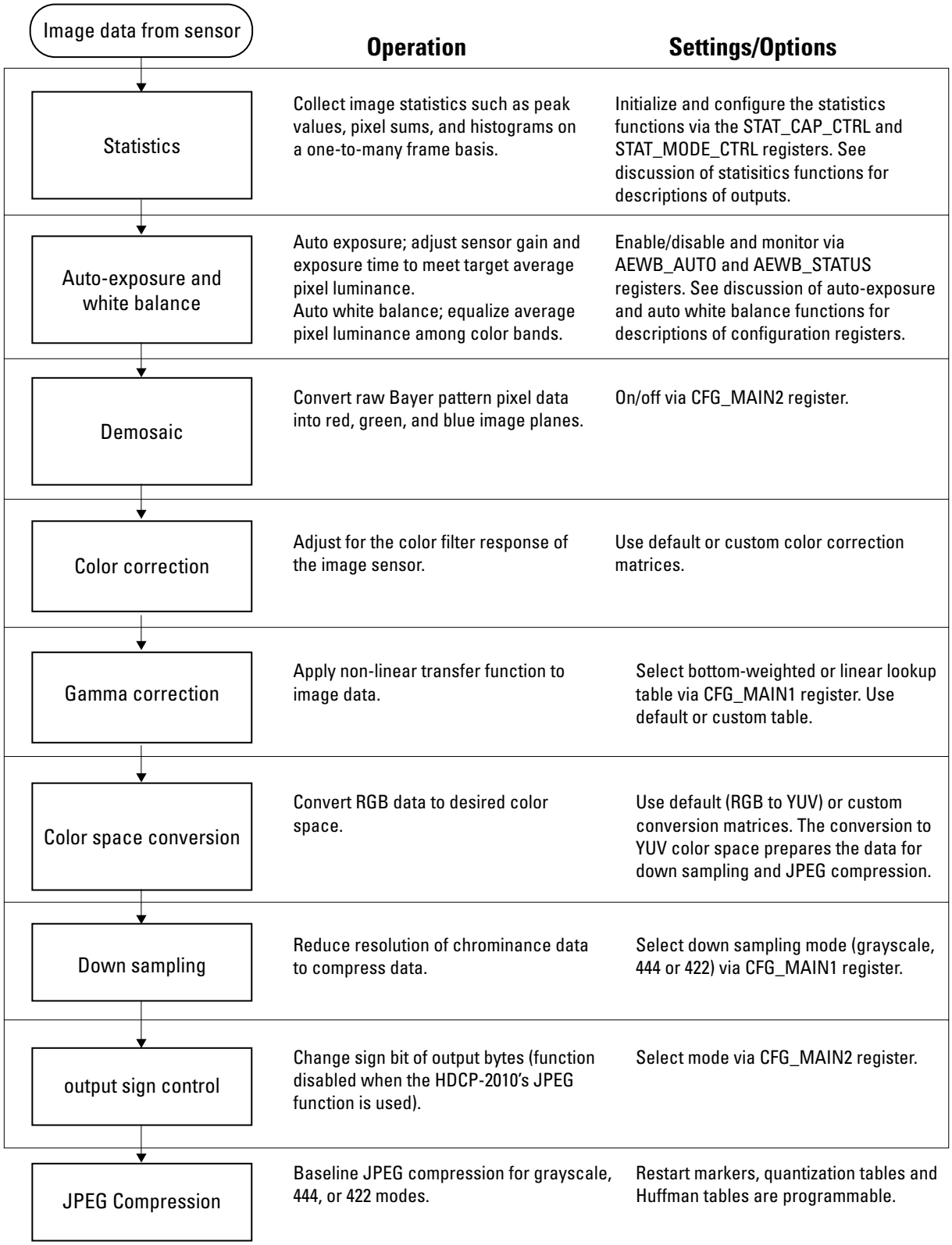
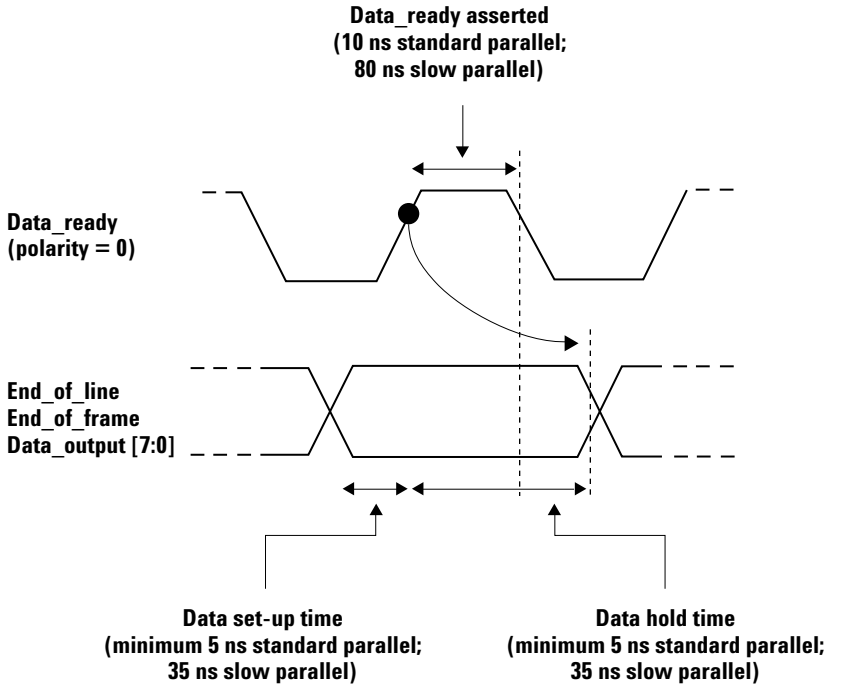
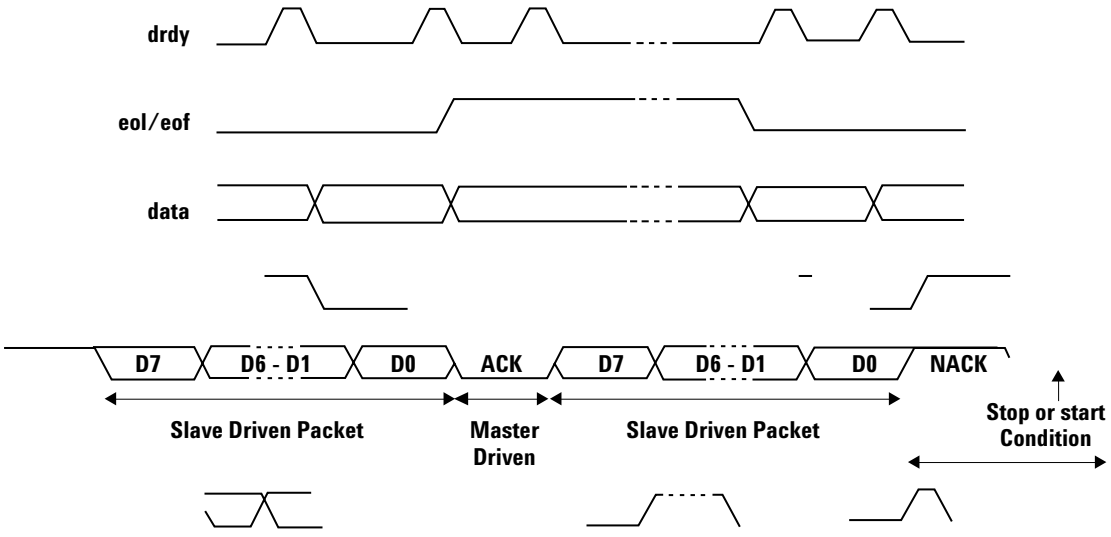


Figure 3. Overview of Image Processing Operations.

Parallel Interface

Parallel mode outputs 8-bit parallel data gated by a data ready line. End-of-line, and end-of-frame signals are available for synchronization.





Serial Interface

In this mode, the Data bit 7 line is used to output serial data gated by a data_ready line. End-of-line acts as a framing bit for every 8-bits of data. End-of-frame signal is available for synchronization.

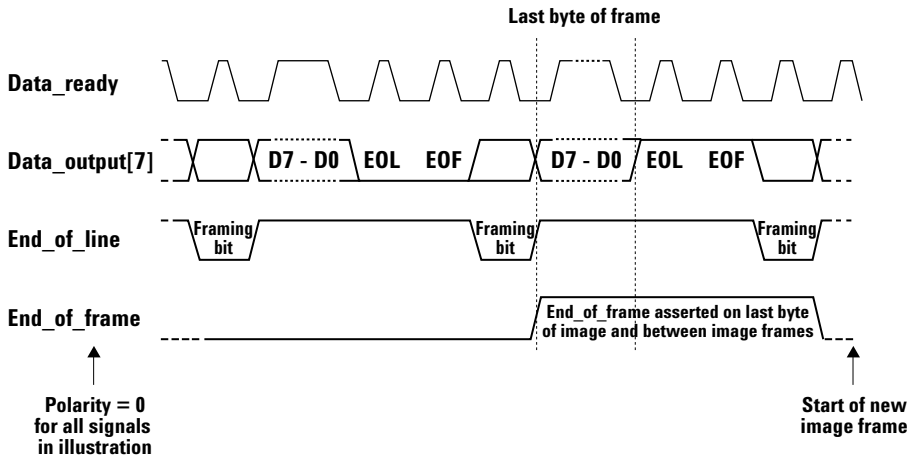


Table 8. Serial Mode Data Transmission Timing by Image Mode.

Mode	Timing (clocks)	Comment
YUV 4:4:4	33 clocks/pixel	11 clocks/component, 3 components/pixel
YUV 4:2:2	22 clocks/pixel	Down sampled 2 components/pixel
Grayscale	11 clocks/pixel	
JPEG	11 clocks/compressed byte	EOF is valid. EOL is not valid.

Two Wire Serial Control Interface
Completely separate from the HDCP-2010 to image sensor control interface, this serial interface provides access to all HDCP-2010 registers and RAMs. To use the interface, the external device must function as a master device driving the serial transfer clock and initiating all read and write operations. The HDCP-2010 operates only as a slave and drives data on the serial data line only in response to requests from the master device.

General Purpose Input/Output Pins
Two general purpose input/output (GPIO) pins are included. Potential applications include driving LEDs or polling a shutter button. The pins can sink or source 8 mA of power. The GPIO register controls both pins and stores the input/output data.

Absolute Maximum Ratings

Parameter	Symbol	Minimum	Maximum	Units	Notes
Storage Temperature	T_S	-35	85	^{0}C	
Lead Solder Temp			260	^{0}C	For 10 seconds, 1.6mm below seating plane.
Supply Voltage	V_{DD}	-0.5	3.6	V	
ESD			2	kV	All pins, human body model MIL 883 Method 3015
Input Voltage	V_{IN}	-0.5	3.6	V	All I/O pins

Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units	Notes
Operating Temperature	T_A	-25		65	°C	
Power Supply Voltage	V_{DD}	1.7	1.8	1.9	Volts	
Vdd low Power Mode Current	Idd				mA	
Vdd Current	Idd	2	32	100	mA	No application running
Vdd Current	Idd	2	47	100	mA	Application running
Power Supply Voltage	V_{DDD}	3.15	3.3	3.45	Volts	
Vddd Low Power Mode Current	Iddd				mA	
Vddd Current	Iddd	2	.8	15	mA	No application running
Vddd Current	Iddd	2	3.4	15	mA	Application running
Cystal Frequency	f_{clk}	16	16	16	MHz	Using external crystal
Oscillator Frequency	f_{clk}	48	48	48	MHz	Using external oscillator
External Clock Pulse Width		9			nS	Minimum high or low pulse width
External Clock Duty Cycle		45	50	55	%	
Crystal Impedance	X_{RES}			55	Ω	

AC Electrical Specifications

Electrical Characteristics over recommended operating conditions. Typical values at 25°C, V_{DD} = 5.0 V

Parameter	Symbol	Min.	Typical	Max.	Units	Notes
Frame Rate				30	frames/sec	640 x 480 VGA sensor
Frame Rate				80	frames/sec	352 x 288 CIF sensor

DC Specifications for General I/O Pins

Symbol	Parameter	Minimum	Maximum	Units	Notes
Vil	Input low voltage	0.0	0.3 x Vdd	V	
Vih	Input high voltage	0.7 x Vddd	Vddd	V	
Vol	Output low voltage	GND	0.4 0.1	V V	At specified drive strength Iol = 20 µA
Voh	Output high voltage	2.4 Vddd-0.1		V V	At specified drive strength Ioh = 20 µA
Ili	Input leakage current	-10.0	+10.0	µA	
Ilo	Tri-state output leakage current	-10.0	+10.0	µA	
Cin	Input capacitance		5.2	pF	
Cout	Output capacitance		5.2	pF	

DC Specifications for Crystal_input and Crystal_output Pins

Table 9. DC specifications for Crystal_input and Crystal_output Pins.

Symbol	Parameter	Minimum	Maximum	Units	Notes
Vil	Input low voltage	0.0	0.3 x Vdd	V	
Vih	Input high voltage	0.7 x Vdd	Vdd	V	
Cin	Input capacitance		0.8	pF	

Programmable Registers

Register Name	Address	Reset Default Value
AE_TARGET: Auto Exposure Target Register	0x009c	0x0040
AEWB_AUTO: Auto Exposure and White Balance Auto Function Register	0x0088	0x0304
AEWB_STATUS: Auto-Exposure and White Balance Status Register	0x008a	0x0000
APS_COEF_GRN0 APS_COEF_RED APS_COEF_BLUE APS_COEF_GRN1 Color Gain Coefficient Registers	0x001a 0x001c 0x001e 0x0020	0x0080 0x0080 0x0080 0x0080
AWB_BLUE_DEFAULT: Default Blue/Green Ratio Register	0x00ac	0x00f3
AWB_BLUE_MAX: Maximum Blue/Green Ratio Register	0x00aa	0x0140
AWB_BLUE_MIN: Minimum Blue/Green Ratio Register	0x00a8	0x0080
AWB_RED_DEFAULT: Default Red/Green Ratio Register	0x00a6	0x009a
AWB_RED_MAX: Maximum Red/Green Ratio Register	0x00a4	0x00d3
AWB_RED_MIN: Minimum Red/Green Ratio Register	0x00a2	0x0080
BLUE_SUM: Blue Sum Data Register	0x00be	0x0000
CC_COEF_00 Color correction coefficient 00	0x0030	0x01ba
CC_COEF_01 Color correction coefficient 01	0x0032	0x037e
CC_COEF_02 Color correction coefficient 02	0x0034	0x03c8
CC_COEF_10 Color correction coefficient 10	0x0036	0x0395
CC_COEF_11 Color correction coefficient 11	0x0038	0x0184
CC_COEF_12 Color correction coefficient 12	0x003a	0x03e7
CC_COEF_20 Color correction coefficient 20	0x003c	0x03c5
CC_COEF_21 Color correction coefficient 21	0x003e	0x03bc
CC_COEF_22 Color correction coefficient 22	0x0040	0x017f
CC_OFFSET_0	0x0042	0x0000
CC_OFFSET_1	0x0044	0x0000
CC_OFFSET_2	0x0046	0x0000
CSC_COEF_00	0x0048	0x0026
CSC_COEF_01	0x004a	0x004b
CSC_COEF_02	0x004c	0x000f
CSC_COEF_10	0x004e	0x01ea
CSC_COEF_11	0x0050	0x01d6
CSC_COEF_12	0x0052	0x0040
CSC_COEF_20	0x0054	0x0040
CSC_COEF_21	0x0056	0x01ca
CSC_COEF_22	0x0058	0x01f6
CSC_OFFSET_0	0x005a	0x0000
CSC_OFFSET_1	0x005c	0x0080
CSC_OFFSET_2	0x005e	0x0080
GAMMA_RED	0x0100 +	2.6
GAMMA_GREEN	0x0200 +	
GAMMA_BLUE	0x0300 +	
GAMMA_ALL	0x0400 +	

Programmable Registers, continued

Register Name	Address	Reset Default Value
CFG_MAIN1: Main Configuration Register 1	0x0002	0x0046
CFG_MAIN2: Main Configuration Register 2	0x0004	0x80f0
ETIME_DEFAULT: Default Exposure Time Register	0x0094	0x00d7
ETIME_MAX: Maximum Exposure Time Register	0x0092	0x01e0
ETIME_MIN: Minimum Exposure Time Register	0x0090	0x0001
GAIN_MAX: Maximum Gain Register	0x008e	0x0a0c
GAIN_MIN: Minimum Gain Register	0x008c	0x0042
GPIO: General Purpose Input/Output Register	0x0006	0x0092
GREEN_SUM: Green Sum Data Register	0x00bc	0x0000
NEG_CLIP_CNT: Negative Clip Count Register	0x00b4	0x0000
OVER120: 1/120th Second Exposure Time Register	0x009a	0x0035
OVER30: 1/30th Second Exposure Time Register	0x0096	0x00d7
OVER60: 1/60th Second Exposure Time Register	0x0098	0x006b
PEAK_DATA: Peak Sensor Data Register	0x00b8	0x0000
PLL_CTRL: PLL Control Register	0x0008	0x0112
PLL_DIVBY: PLL Divby Coefficient Register	0x0014	0x0024
PLL_M: PLL M Coefficient Register	0x0010	0x0000
PLL_PCNT0: PLL P0 Coefficient Register	0x000e	0x0078
PLL_PCNT1: PLL P1 Coefficient Register	0x000c	0x0078
PLL_QCNT: PLL QCNT Coefficient Register	0x000a	0x0007
PLL_SUM: PLL SUM Coefficient Register	0x0012	0x0000
POS_CLIP_CNT: Positive Clip Count Register	0x00b6	0x0000
QSCALE_FACTOR: JPEG Quantization Scale Factor Register	0x0062	0x0100
QSCALE_FACTOR_DEC: JPEG Q Factor Decrement Register	0x0064	0x0001
QSCALE_FACTOR_INC: JPEG Q Factor Increment Register	0x0066	0x0004
RED_SUM: Red Sum Data Register	0x00ba	0x0000
RESTART: JPEG Restart Marker Interval Register	0x0060	0x0000
REV: Revision Register	0x0000	Revision
STAT_ACC: Statistics Sum Accumulator Register	0x00b2	0x0000
STAT_CAP_CTRL: Image Statistics Capture Control Register	0x00ae	0x0000
STAT_MODE_CTRL: Image Statistics Mode Control Register	0x00b0	0x0000
TWIN_ADDR: Two Wire Serial Interface Address Register	0x0080	0x0000
TWIN_CTRL: Two Wire Serial Interface Control Register	0x0086	0x0000
TWIN_DATA0: Two Wire Serial Interface Data Word 0 Register	0x0082	0x0000
TWIN_DATA1: Two Wire Serial Interface Data Word 1 Register	0x0084	0x0000
UFL_THRESHOLD: Auto Q Adjust Underflow Threshold Register	0x006c	0x0380
Histogram Registers Green0 Red Blue Green1	 0x0e00 + 0x0e28 + 0x0e50 + 0x0e78 +	

Pin Drive Strength

Table 10. Pin Drive Strength.

Pin	Drive Strength (mA)	Pin	Drive Strength (mA)
Data_output[0]	8	nPOR	4
Data_output[1]	8	Sensor_clock	8
Data_output[2]	8	Sensor_data[0]	4
Data_output[3]	8	Sensor_data[1]	4
Data_output[4]	8	Sensor_data[2]	4
Data_output[5]	8	Sensor_data[3]	4
Data_output[6]	8	Sensor_data[4]	4
Data_output[7]	8	Sensor_data[5]	4
Data_ready	8	Sensor_data[6]	4
End_of_frame	8	Sensor_data[7]	4
End_of_line	8	Sensor_data[8]	4
GPIO_0	8	Sensor_data[9]	4
GPIO_1	8	Sensor_data_ready	4
IPC_TWIN_sclk	4	Sensor_nFrame	4
IPC_TWIN_sdata	4	Sensor_nReset	4
Mode_select[0]	4	Sensor_nRow	4
Mode_select[1]	4	Sensor_TWIN_clock	4
Mode_select[2]	4	Sensor_TWIN_data	4

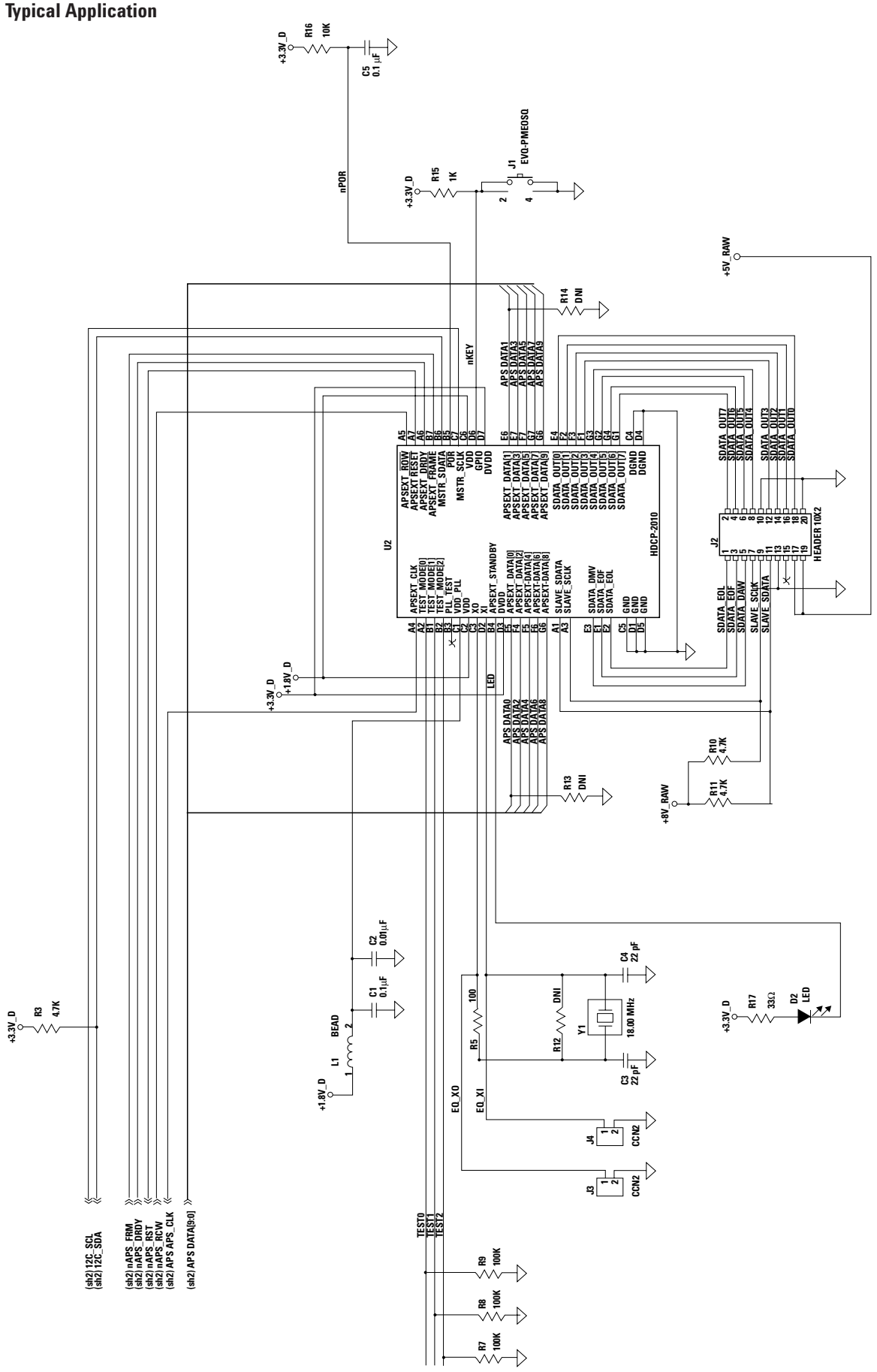
Input Signal Timing Specifications

Table 11. Timing for Input Signals.

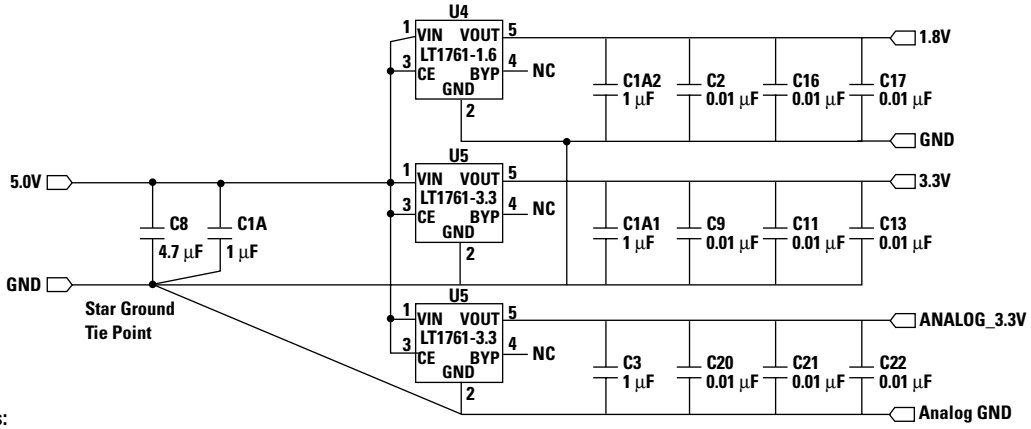
Pin	Minimum Time High (internal clocks)	Minimum Time Low (internal clocks)
GPIO_0, GPIO_1	2	2
IPC_TWIN_sclk	4	4
IPC_TWIN_sdata	4	4

Default system clock speed = 48 MHz

Typical Application



Typical Application, continued



Notes:

Analog ground should be kept separate from digital ground and tied together at the star ground tie point.

March 5, 2001
5988-2096EN

Agilent Technologies