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Full Frame Image Sensors Evaluation Board User's Manual



ON Semiconductor®

<http://onsemi.com>

EVAl BOARD USER'S MANUAL

Introduction

The Full Frame Evaluation Board provides a powerful platform to quickly and easily evaluate a number of ON Semiconductor Full Frame Image Sensors in a prototype imaging system. The Evaluation Kit also serves as a useful reference design that will save considerable time and cost in the development of a product prototype. The programmable logic architecture, bias supplies, clock drivers and analog signal processing chain can be readily used, with application specific modifications, in a camera production design.

The Evaluation Board is designed to be flexible, and has the ability to operate many different Full Frame image sensors at different operating frequencies. Consult ON Semiconductor to obtain information for optimizing the reference design to operate a specific image sensor at a specific operating frequency.

Overview

The Full Frame Evaluation Board serves as a complete, self-contained, CCD image acquisition sub-system. The user simply applies power, and an IMAGE_ACQUIRE TTL pulse to begin capturing digital images. Differential TTL frame grabber sync pulses (Frame, Pixel and Line rate) are provided to facilitate easy connection to a frame grabber.

In the still capture mode, application of the IMAGE_ACQUIRE signal results in flushing of the CCD, then integration, then clocking out of a full frame of image data. In free-run mode, an acquisition signal is not needed; the board is free running and continuous frames of 12 bit information stream out.

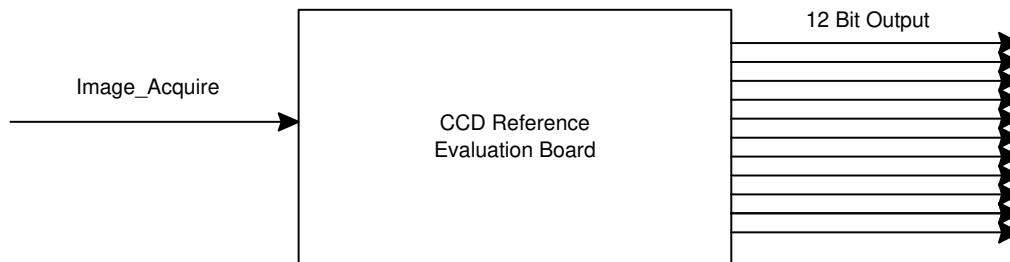


Figure 1. Block Diagram (Overview)

SPECIFICATIONS

Maximum Data Rate: 6 MHz
Resolution: 12 Bits
Frame Rate: Depends on Data Rate, CCD Array Size, and Integration Time

Outputs

D[11..0]: Differential TTL
Frame Grabber Syncs: Differential TTL
Integration Sync: TTL

Inputs

Serial Clock: 10 MHz Maximum
PGA Gain Range: 1X to 6X
PGA Gain Resolution: 256 Steps
Offset Range: -100 mV to +100 mV
Offset Resolution: 256 Steps
Temperature Range Board: 0 – 70°C
Temperature Range CCD: -50 to +70°C Typical

Table 1. POWER SUPPLY REQUIREMENTS

Power Supplies				Typical Current Switching Power Supply	
Supply	Minimum	Nominal	Maximum	Disabled	Enabled
+5 V	+4.9 V	+5 V	+5.1 V	1000 mA	1500 mA
+18 V	+17 V	+18 V	+20 V	120 mA	–
–18 V	–20 V	–18 V	–13 V	100 mA	–

Electrons per A/D count – 29.2 @ 5 MHz, 2.5X Gain setting (Assuming on-chip CCD amplifier gain of 10 μ V/electron).

RMS Dark Noise – 1.9 LSB typical @ 5 MHz, 2.5X Gain setting.

System Noise Floor – 56 electrons @ 5 MHz, 2.5X Gain setting (Assuming on-chip CCD amplifier gain of 10 μ V/electron).

ARCHITECTURE OVERVIEW

A complete Block Diagram of the Evaluation Board is shown in Figure 3.

Master Clock

The Master Clock runs at eight times the Pixel clock frequency. The maximum pixel clock frequency is 6 MHz, which yields a maximum system clock frequency of 48 MHz. For slower Pixel clock frequencies, decrease the master clock frequency. The Default setting of the evaluation board is a 40 MHz system clock, with a pixel clock frequency of 5 MHz.

The KAF–4301 is an exception to this. It provides pixel frequencies of 2.5 MHz and 1.25 MHz by dividing the 40 MHz master clock by 16 and 32. The pixel frequency is selected using SW2. This is an 8-position switch that usually selects a CCD binning mode (See section Binning Modes). The KAF–4301 timing program does not support binning at this time and, instead, uses this switch to select the pixel rate (See Table 8). The pixel rate is 1.25 MHz when SW2 is set to position 0 and 2.5 MHz when set in any other position.

PLD1

PLD1 contains the Clocking State Machine that controls the operational flow of the evaluation board (Figure 4). PLD1 generates the CCD clock timing, A/D converter timing and frame grabber sync signals. The PLD1 controls the image line and frame length [dependent upon the CCD switch settings], as well as the horizontal and vertical CCD clock timing [dependent upon the binning mode BIN switch settings.]

PLD2

PLD2 controls the integration timing, which is dependent upon the INT switch settings. PLD2 also programs the AD9816’s registers to a default condition upon power up via

a three wire serial interface. Additionally, if the user chooses to adjust the AD9816’s register settings, the PLD2 controls the programming of these registers.

CCD Clock Drivers

Elantec clock drivers, designed to drive the large capacitance loads presented by the clock gates of the CCD, are used to generate the horizontal and vertical clocks. The Elantec drivers accept TTL inputs, and level shift to the required peak-to-peak voltage swing of the CCD clocks. The peak-to-peak swing of the clocks is adjustable. The outputs of the drivers are AC coupled, providing adjustable offset of the clocks from the negative rail to the positive rail. Using a separate IC for each vertical clock (V1, V2), a maximum 4 amp output drive current per vertical clock channel is available. A single IC is used to drive H1, and H2, giving a maximum 2 A output drive current per Horizontal clock channel.

The reset clock driver utilizes two fast switching transistors, designed for a fast switching input signal with a narrow pulse width. The peak-to-peak voltage swing and the offset voltage are adjustable.

CCD Bias Voltages

CCD bias voltages (VRD, VOG, VLG) are supplied by filtered outputs of adjustable potentiometers. Fixed CCD bias voltages (LOD, VSS, GUARD) are supplied by filtered outputs of voltage dividers.

CCD Image Sensor

This evaluation board supports the following Full Frame CCD image sensors: KAF–0261, KAF–0402, KAF–1001, KAF–1603, KAF–3200, KAF–6303, KAF–16801, and KAF–4301.

A/D Converter Analog Devices AD9816

The AD9816 is a 12 bit, 6 MSPS CCD analog signal processor. The IC provides an integrated correlated double sampling (CDS), 8 bit programmable gain, and 8 bit DC offset adjust. Timing signals are provided by PLD1. Default register values are downloaded from PLD2 upon power up. Alternate programming of its registers can be achieved via external serial interface or by manually setting the address and data switches on the board and pressing the capture button.

Emitter Follower

The video out of the CCD is buffered using a bipolar junction transistor in the emitter follower configuration.

AC Coupling Capacitor

A 1200 pF input coupling capacitor removes the DC component of the video signal.

Power On Clear/Reset

Resets and initializes the board on power up or when the Reset button is pressed.

JTAG Header

A 10-pin header provides the user with the ability to reprogram the Altera 7000S PLDs in system via Altera's ByteBlaster programming hardware.

Unit Integration Time

The amount of time the CCD is exposed to light before clocking out the accumulated charge is called the integration time. An RC circuit and Schmitt trigger inverter are used to set the unit integration time. Total integration time is a multiple of the unit integration time.

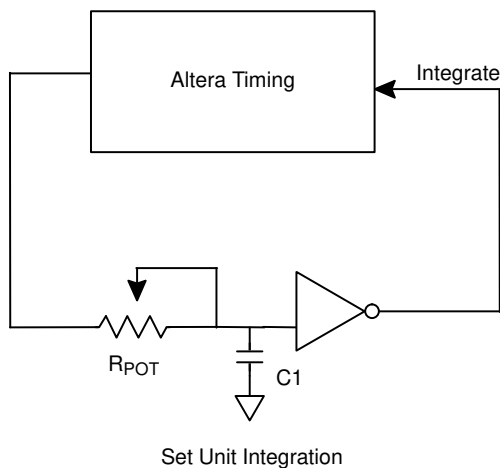


Figure 2. Unit Integration Timing Adjustment

The circuit is set to toggle at 100 Hz, providing a fixed unit integration time of 10 ms. The actual integration time is set to a multiple of the unit integration time using an internal integration counter in PLD2. The user can choose an integration time from 10 ms to 10 seconds by setting the integration switches appropriately (See Table 9).

J6 Input Connector

This connector is used to input control signals to the evaluation board. This is an optional feature; all control lines can be set via on-board switches. Images can be acquired using the on-board image capture button. No external digital inputs are needed to acquire images.

J4 Output Connector

The J4 output connector provides 12 bits of video data in RS422 differential TTL format. J4, additionally, provides three frame grabber sync signals in differential TTL format.

J7 Integration Sync

This connector provides a sync signal that is high during the integration time period. The signal can be used to sync a shutter or LED light source to the evaluation board, and can source up to 80 mA at 5 V.

J1, J2 Imager Board Connectors

CCD Daughter Boards plug into these connectors. The daughter boards route the clock and bias traces from the timing board to the proper pins of the CCD.

Power Supplies

An onboard switching supply provides all of the voltages necessary to operate the CCD Digital Reference Evaluation Board, from a single +5 V source.

Switching supplies can, however, be a source of low-level asynchronous noise. If asynchronous noise is present and objectionable in an application, the internal switching supply can be disabled and external low-noise linear supplies can be used to power the board. The procedure for configuring the board to accept external supplies is detailed Under Power Supply Modes

J5 Power Connector

The power connector is a 5-pin connector with +5 V, +18 V, -18 V and two AGND connections. If the switching power supply is used to generate the +15 V and -10 V supplies, then only an external +5 V supply needs to be brought in through J5. Otherwise, all three power supplies must be connected to the board via J5.

BOARD REQUIREMENTS

Power Supply

The board requires only a single +5 V, 1.5 Amp or greater power supply to operate. An on board switching power supply generates the necessary +15 V, 120 mA and -10 V, 120 mA power supplies from the 5 V input. Although extensive filtering is done on board, the power supplied to the board must be quiet and stable in order to achieve the best possible performance. (See Power Supply Modes, for an alternative way to power the board.)

Inputs

In the Free-Run mode, the evaluation board requires no input signals to begin acquiring images.

In Still mode, the evaluation board will acquire a single image on the falling edge of the Image_Acquire control line. This can be accomplished via the push button (S4) or, remotely, by utilizing the Image_Acquire control line.

See Section Still/Free-Run Modes for more information on Still and Free-Run modes.

See Sections Line/Switches Modes and AD_IN/EX Modes for information on additional optional inputs.

Outputs

D[11..0] (\pm) – 12 bits of Differential TTL Digital information

INTEGRATE – A signal provided to allow the user to synchronize the strobing of LED illuminators or opening of a shutter, during the integration period.

FRAME (\pm)* – Differential TTL Frame grabber vertical sync signal.

LINE (\pm)* – Differential TTL Frame grabber horizontal sync signal.

PIX (\pm)* – Differential TTL Frame grabber pixel sync

*These sync signals can be modified if necessary to accommodate different Frame Grabbers.

JTAG Programming

Altera 7000S In System Programmable (ISP) PLD's are used on this board. A ten-pin header (J8) is provided to allow for the programming of these PLD's. Since these parts are re-programmable, custom digital logic can be implemented for timing and mode adjustments or additions. Any custom implementation can be made quickly and easily to via the JTAG programming interface provided by this connector.

CONFIGURATION MODES

The following modes of operation are available to the user:

Line/Switches Modes

The Line/Switches Jumper (SW5) selects whether some of the board settings will be controlled externally through the J6 connector (Line), or via the on-board switches (Switches). If this switch is set to Line, then the integration time and the binning mode must be set remotely via digital I/O. The still/free-run mode switch (SW3, 3-position switch) can also be set externally when the Line mode is selected. Set SW3 to the middle position if it is desired to control this line externally.

Still/Free-Run Modes

The "Still/Free-Run" switch (SW3) is a three-position switch that selects whether the board will operate in the still mode, or a free-running mode.

If SW3 is placed in the middle position ("LINE"), the image capture mode is determined by the voltage on the STILL/FREE-RUN pin on the input connector (J6-27). Setting this line LOW selects the free-run mode, and setting it HIGH selects the still mode.

In still mode, the Image_Acquire control line must be strobed in order to acquire a single image. This is

accomplished by either pressing the on-board acquire button (S4) or, remotely, bringing the Image_Acquire line low and then back high. The detection of the falling edge of this signal starts the image acquisition process.

The still mode acquisition process is as follows:

1. The CCD is flushed of all accumulated charge.
2. The CCD is exposed to light during the integration time.
3. The image is clocked out of the CCD. The system then waits for the next Image_Acquire signal.

In the Free-Run mode, the system will continuously capture images and clock them out. No flushing is done, as the clocking out of the previous image serves this same purpose.

See Figure 4 for the Clocking State Machine Diagram.

AD_IN/EX Modes

The board comes with an Analog Devices AD9816 12 bit A/D converter on board. This A/D has several features, such as multiple configurations, programmable gain, and offset registers which require initialization and/or programming on power up. The programming of these registers is done via a three wire serial interface.

EXT

A three wire serial interface is provided on the J6 connector of the board, and the AD9816 registers can be controlled remotely via these when the A/D_IN/EX Jumper (SW4) is set to EXT. See Figure 5 for AD9816 serial timing diagrams and information.

INT

If it is not desired to control the programming of the A/D's registers remotely, set Jumper SW4 to INT. PLD2 contains a state machine that serially loads in the following default values to these registers upon power up.

A/D Default Register Settings:

No. of channels: 1
 Mode: CDS Mode
 Input Span: 3 V
 Channel Selected: Green
 Red PGA Gain*: 1
 Green PGA Gain: 1
 Blue PGA Gain*: 1
 Red Offset*: 0 mv
 Green Offset: 0 mv
 Blue Offset*: 0 mv

*Although the Red and Blue channels are not used, these registers are still initialized to these default settings.

Adjustments

Adjustments can be made to the A/D registers during operation of the board by utilizing the DATA dipswitch (SW10), the ADDRESS switch (SW9), and the Image_Acquire control line. After setting SW9 to the desired Address, and SW10 to the desired Data, send an Image_Acquire signal either by pressing the Image_Acquire button or remotely via the J6 connector control line. This will load the new value into PLD2 and a state machine inside the PLD will then serial load the new data into the A/D's register. This is true whether or not the board is running in Still or Free Run Mode. (See Figure 5 for more information on the AD9816 registers.)

CCD Modes

The CCD Select switch (SW1) setting determines the line and frame length timing.

This switch is pre-set at ON Semiconductor. (See Table 5)

Binning Modes

The BIN Select switch (SW2) setting determines the Binning mode operation. (Table 6)

Integration Modes

The INT Select switches (SW6, SW7) settings determine the Integration Time.

SW6 is the Coarse Adjust. SW7 is the Fine Adjust. (Table 9)

Frame Grabber Diagnostic Modes

When set to ENABLE, the Sync_Test_Enable switch (SW12) tri-states the 12-bit output bus out of the A/D converter, and enables the output of either the pixel number or the line number onto the output bus, depending on how the Sync_Test_pix/line Jumper is set (SW11). This provides a diagnostic test to make certain the Frame Grabber is synchronized correctly with the board.

The line counter in PLD1 is a binary up-counter, therefore the line count that is output to the output bus will increment sequentially (0, 1, 2, 3, 4, 5...) until the last line in the frame.

The pixel counter in PLD1 is a gray code up counter, therefore the pixel count that is output to the output bus will increment in gray code transition counts (0, 1, 3, 2, 6, 7, 5, 4...) until the last pixel in the line.

Power Supply Modes

Power can be supplied to the board in one of two ways:

Switching Power Supply

The board comes supplied with a 500 kHz switching power supply (Linear Technologies LT1372). If it is desired to utilize the on-board switching supply, the board should be configured as follows:

1. Connect a 5 V, 1.5 A or greater lab supply to the J5 power connector.
2. Install Jumper 6 and Jumper 4.
3. Remove Jumper 7 and Jumper 5.
4. Set Jumper 1 to the ON position.

External Supply Operation

To disable the on-board switching supply and operate using external supplies:

1. Remove Jumpers 4 and 6;
2. Install Jumpers 5 and 7;
3. Move Jumper 1 to the "OFF" position to disable the switching power supply;
4. Connect +18 V, -18 V, and +5 V to power input connector J5.

Functionality

The switching supply generates +15 V and -10 V supply "islands". The same is true for the +15 V and -10 V regulators on the board. Jumpers 4 and 6 connect the switcher supplies to the +15 V, -10 V power plane. Jumpers 5 and 7 connect the regulated outputs to the +15 V, -10 V power plane. Jumper 1 either enables or disables the LT1372 Switcher.

CCD IMAGER BOARDS

Each CCD has an imager board. The imager boards route the bias voltage traces from the timing board through connectors J1 and J2 to the appropriate pins on the device. The imager boards contain the Horizontal and Reset clock driver ICs as well as the emitter-follower circuit that buffers and drives the video signal down to the timing board.

LOD/GUARD: +10 V
 VSUB: 0 V
 VSS: 0 to +2.1 V

NOTE: The VSS bias voltage is set by the inclusion of up to three series diodes on the imager board. Therefore 0 V is achieved by shorting across all three diode positions. This bias is preset at the factory depending on the appropriate CCD specification.

Adjustments

Fixed Bias Voltages

Fixed Voltages:

VDD: +15 V

Variable Bias Voltages (see Table 2)

Table 2. VARIABLE BIAS VOLTAGES

Variable Voltage (Note 1)	Function	Adjustment Potentiometer
VOG		R12
VRD		R11
VLG		R13
V_PP	(Vertical clk Peak to Peak Swing)	R17
VCLK	(Vertical clk Level Adjust)	R67
H_PP	(Horizontal clk Peak to Peak Swing)	R64 (Imager Board)
HCLK	(Horizontal clk Level Adjust)	R14 (Imager Board)
R_PP	(Reset clk Peak to Peak Swing)	R18 (Imager Board)
RCLK	(Reset clk Level Adjust)	R27 (Imager Board)

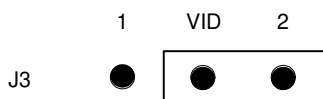
1. These voltages are optimized for the particular KAF Series image sensor being used and are fixed at the factory according to the image sensor specification. Adjustments should not be made to them without consulting ON Semiconductor.

Output Selection for Sensors with Two Outputs

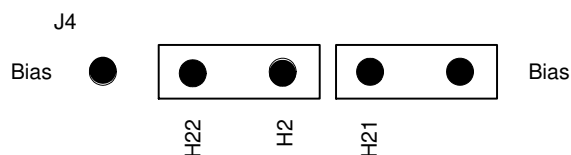
The KAF-1001, KAF-0261, and KAF-4301 sensors have two video outputs. The outputs have different gain and one of them is selected depending on the application. The imager daughter boards for these sensors have two jumpers that must be set correctly to enable the desired output.

To select the high gain output, Vout2:

Set J3 to the VID2 position:

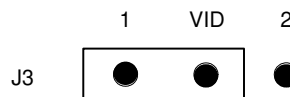


Set the two jumpers on J4 as follows:

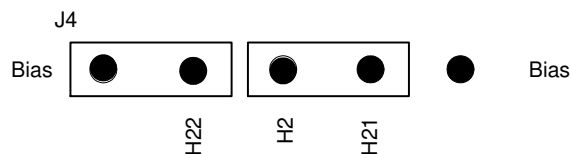


To select the low gain output, Vout1:

Set J3 to the VID1 position:



Set the two jumpers on J4 as follows:



NOTE: The schematic for the KAF-1001 imager daughter board contains an error. The library element for the imager indicates that pin 5 is Vout1 and pin 12 is Vout2. These are incorrect and are reversed in that part of the schematic. However, the labeling on the imager board is correct. Only the pin labeling on the schematic is incorrect.

TIMING

Fixed Timing

H1, H2

Variable Timing

V1, V2 (Binning Modes)

RESET (Binning Modes)

CLAMP (Binning Modes)

SAMPLE (Binning Modes)

A/D Clock (Binning Modes)

See Timing Diagram 1 – Figure 6

See Timing Diagram 3 – Figure 14

NOTE: Not available with the KAF-16801 and KAF-4301 image sensors.

OTHER PARAMETERS

Fixed Parameters

Flush Duration: (4000 lines)

Variable Parameters

Pixel frequency: The pixel frequency is 1/8 the master clock. The maximum pixel frequency is 6 MHz. To run the board at a slower pixel rate one must decrease the system clock frequency; being mindful of the 1/8 relationship. (e.g. for a 4 MHz pixel rate, use a 32 MHz system clock)

Line Length: (Depends on CCD mode)

Frame Length: (Depends on CCD mode)

Vwidth: (Depends on pixel frequency, 64 pixel counts wide)

Unit Integration: The integration clock frequency is set by a RC circuit of R6 and C6 and is adjusted to 100 Hz at the factory, creating a unit integration time of 10 ms. By adjusting R6, the unit integration time can be varied. Because all of the integration time settings in Table 9 are multiples of this unit integration time, the values would need to be recalculated for any new unit integration time.

FIGURES, TABLES, TIMING DIAGRAMS, AND PERFORMANCE DATA

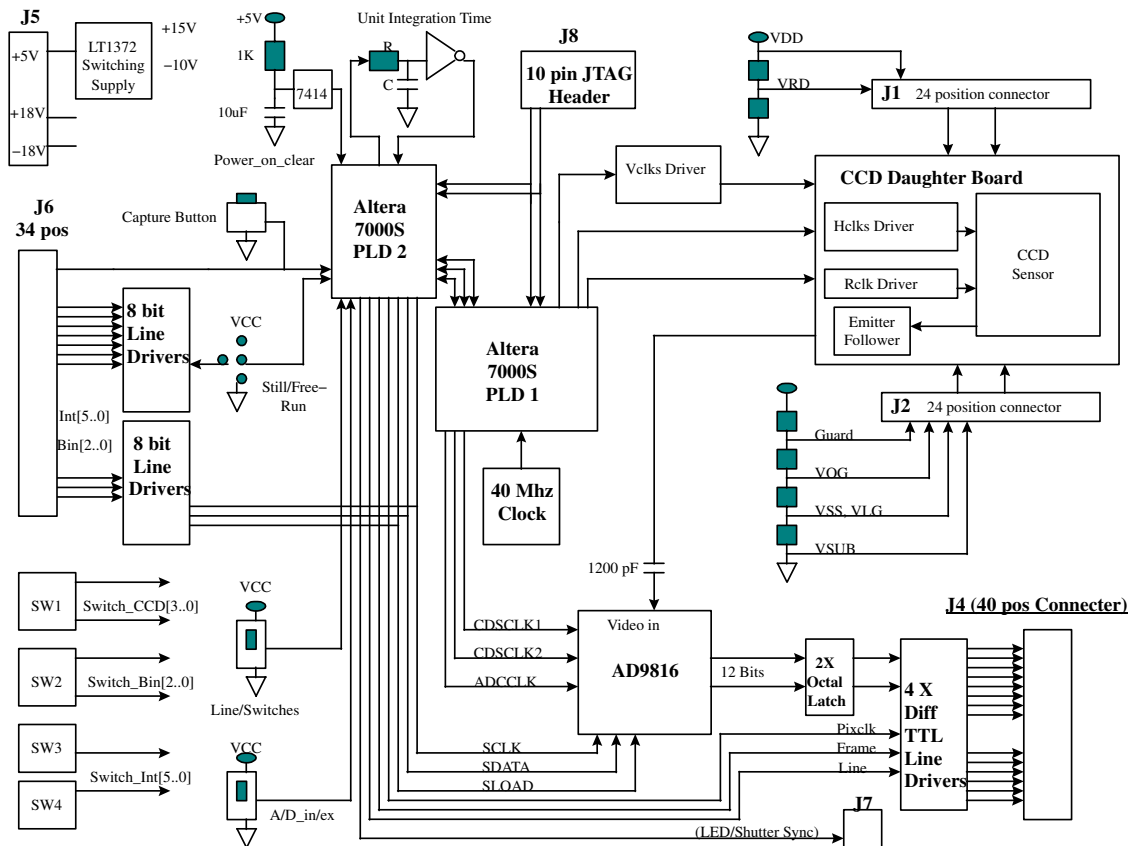
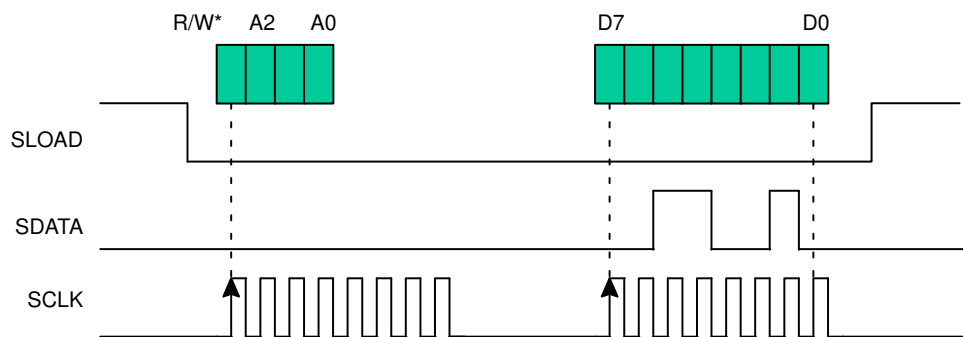


Figure 3. System Block Diagram

Table 3.

Address	Register		Function	Default Programming
0	Configuration Register			
	Bit 7 MSB	Test Mode Bit	Always 0	0
	Bit 6	Test Mode Bit	Always 0	0
	Bit 5	CDS Mode Bit	High for CDS	1
			Low for SHA Mode	1
	Bit 4	Input Span	High for 3 V	1
	Bit 3	Input Span	High for 1.5 V	0
	Bit 2	Channel Mode	High for 3 Channel	0
	Bit 1	Channel Mode	High for 1 Channel	1
	Bit 0	Test Mode Bit	Always 0	0
1	MUX Register			
	Bit 7	Test Mode Bit	Always 0	0
	Bit 6	Channel Sequence	High for BGR	0
	Bit 5	Channel Sequence	High for RGB	0
	Bit 4	Channel Select	High for Red	0
	Bit 3	Channel Select	High for Green	1
	Bit 2	Channel Select	High for Blue	0
	Bit 1	Test Mode Bit	Always 0	0
	Bit 0	Test Mode Bit	Always 1	1
2	Red PGA Register		1X to 6X (Note 2)	0 (1X)
3	Green PGA Register		1X to 6X (Note 2)	0 (1X)
4	Blue PGA Register		1X to 6X (Note 2)	0 (1X)
5	Red Offset Register		-100 mV to 100 mV (Note 3)	0 (0 mV)
6	Green Offset Register		-100 mV to 100 mV (Note 3)	0 (0 mV)
7	Blue Offset Register		-100 mV to 100 mV (Note 3)	0 (0 mV)

- 2. PGA Gain = 1 + (gain code/ 51.2)
- 3. 01111111 = +100 mV, 00000000 = 0 mV, 11111111 = -100 mV



3 Wire Serial Interface Timing

* R/W Low for Write, High for Read

Figure 5. AND9816 Register Configuration

Table 4. BOARD SWITCHES, INPUTS, OUTPUTS

SWITCHES

Line/Switches	Select Where Control of Modes Comes from
Switch_Int[5..0]	Integration Timing Control Lines (See Table 9)
Switch_Bin[2..0]	Binning Mode Control Lines (See Table 6 and Table 7)
Switch_CCD[3..0]	Device Select (See Table 5)
Still/Free-Run	Selects Mode of Operation
A/D_in/ex	Select How A/D Programming is Controlled
Sync_test_pix/line	Select Frame Grabber Diagnostic to be Performed
Sync_test_enable	Enable/Disable Frame Grabber Sync Test

INPUTS

System_clk	8X Pixel Clock (48 MHz Maximum)
integrate_clk	Unit Integration Time clock
Image_Acquire	Still Mode Image Acquisition Command Line, OR, Capture Button Input
Int[5..0]	Integration Timing Control Lines
Bin[2..0]	Binning Mode Control Lines
Serial Clock	For A/D Use
Serial Data	For A/D Use
Serial Load	For A/D Use
JTAG Header	10-pin Header for ISP

OUTPUTS

Dout[11..0] (±)	12 Bits Differential TTL Digital information
FRAME (±)	Differential TTL Frame Grabber Frame Sync Signal
LINE (±)	Differential TTL Frame Grabber Line Sync Signal
PIX (±)	Differential TTL Frame Grabber Pixel Sync Signal
INTEGRATE	Active high signal indicates when in integration state. Can be used to sync LED's or shutter with this state.

Table 5. CCD MODES

CCD Switch Setting	CCD	Pixels/Line	Lines/Frame
0*	Test Mode 0 or KAF-16801	100	2
1	Test Mode 1	1500	1200
2	Test Mode 2	10	4
3	Test Mode 3	1500	1200
4	Test Mode 4	2300	2150
5	KAF-1603	1700	1100
6	KAF-6303	3300	2150
7	KAF-0402	1000	650
8	KAF-3200	2300	1600
9	KAF-1001	1200	1150
A	KAF-0261	700	650
B	KAF-16801	4300	4200
C	KAF-4301	2300	2200

NOTE: In order to operate the KAF-16801 sensor using the KAF Series CCD Digital Reference Evaluation Board, the board is configured with a unique PLD program. This is the switch setting for the KAF-16801 for that case. When the board is configured for the KAF-16801, this mode will produce 4300 pixels per line and 4200 lines per frame. For all the other sensors, this is a test mode as described in the table.

Table 6. BINNING MODES

Bin Switch Setting	Binning Mode
1	1x1 (No Binning)
2	2x2
3	3x3
4	4x4
5	5x5
6	6x6
7	8x8
0	10x10

NOTE: Binning Mode is not included in the timing program for the KAF-16801 and KAF-4301 image sensors.

Table 7. BINNING MODES WHEN CONFIGURED FOR USE WITH KAF-16801

Bin Switch (SW2) Setting	Binning Mode
1	1x1 (No Binning)
2	1x1 (No Binning)
3	1x1 (No Binning)
4	1x1 (No Binning)
5	1x1 (No Binning)
6	1x1 (No Binning)
7	1x1 (No Binning)
0	1x1 (No Binning)

NOTE: In order to operate the KAF-16801 sensor using the KAF Series CCD Digital Reference Evaluation Board, the board is configured with a unique PLD program. That PLD program does not support binning modes other than 1x1 (normal full resolution readout).

Table 8. KAF-4301 SW2 PIXEL RATE SETTINGS

KAF-4301E SW2 Setting	Pixel Rate
0	1.25 MHz
1...7	2.5 MHz

Table 9. INTEGRATION TIME MODES

SW7 Switch Setting (Coarse)	INT 5-3 Switch (Coarse)	Integration Time (Seconds)
0	0	0
1	1	1
2	10	2
3	11	3
4	100	4
5	101	5
6	110	7
7	111	9
SW6 Switch Setting (Fine)	INT 2-0 Switch Setting (Fine)	Integration Time (ms)
0	0	0 (Note 4)
1	1	20
2	10	50
3	11	100
4	100	200
5	101	300
6	110	500
7	111	800

4. If both SW7 and SW6 are set to zero, the integration time is set to 10 ms.

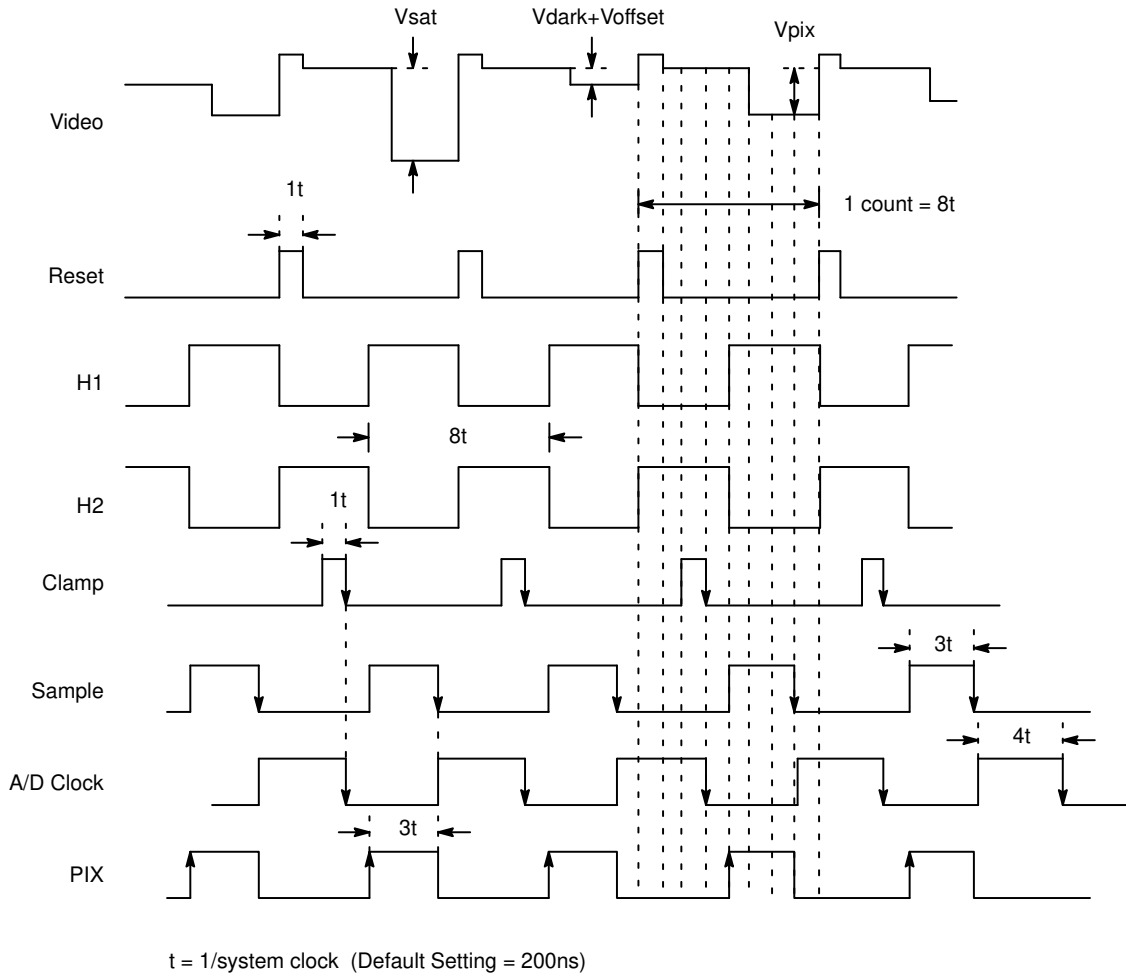


Figure 6. Pixel Rate Timing

NOTE: The KAF-4301 implements $16t = 1\text{pixel}$ and $32t = 1\text{ pixel}$ modes instead of the $8t = 1\text{pixel}$ timing. This provides pixel frequencies of 2.5 MHz and 1.25 MHz.

EVBUM2257/D

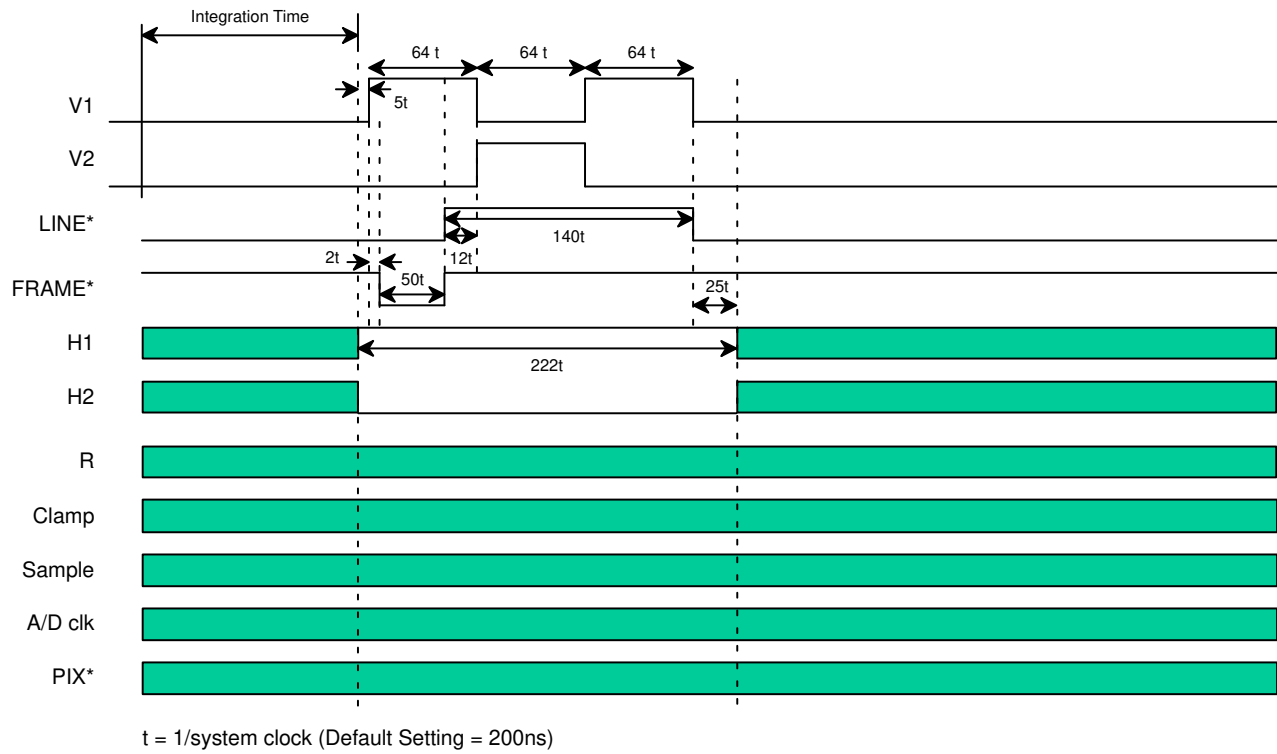


Figure 7. Line Rate Timing for KAF-0261, 0402, 1001

NOTE: The line rate timing for the KAF-4301 is similar to this with the addition of an overlap period in the vertical clock timing. Consult the current specification for the KAF-4301 for details.

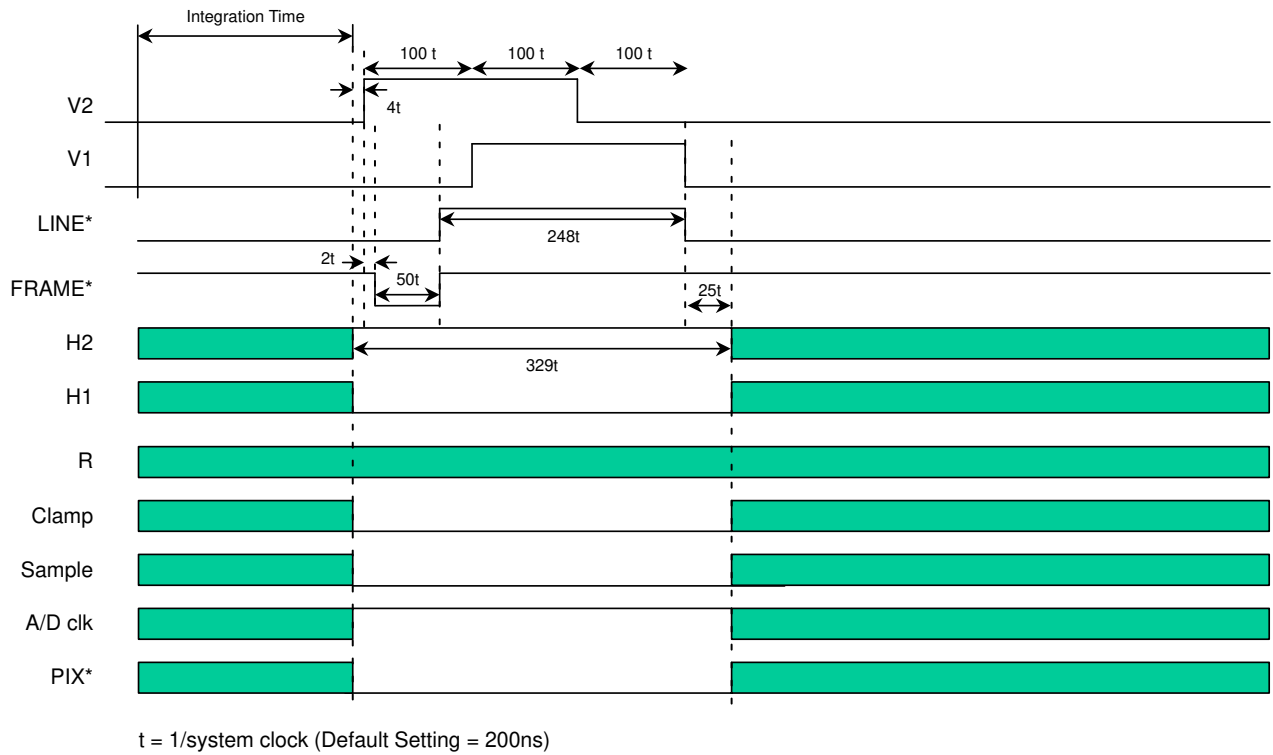


Figure 8. Line Rate Timing for KAF-16801 Sensors

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Frame Timing

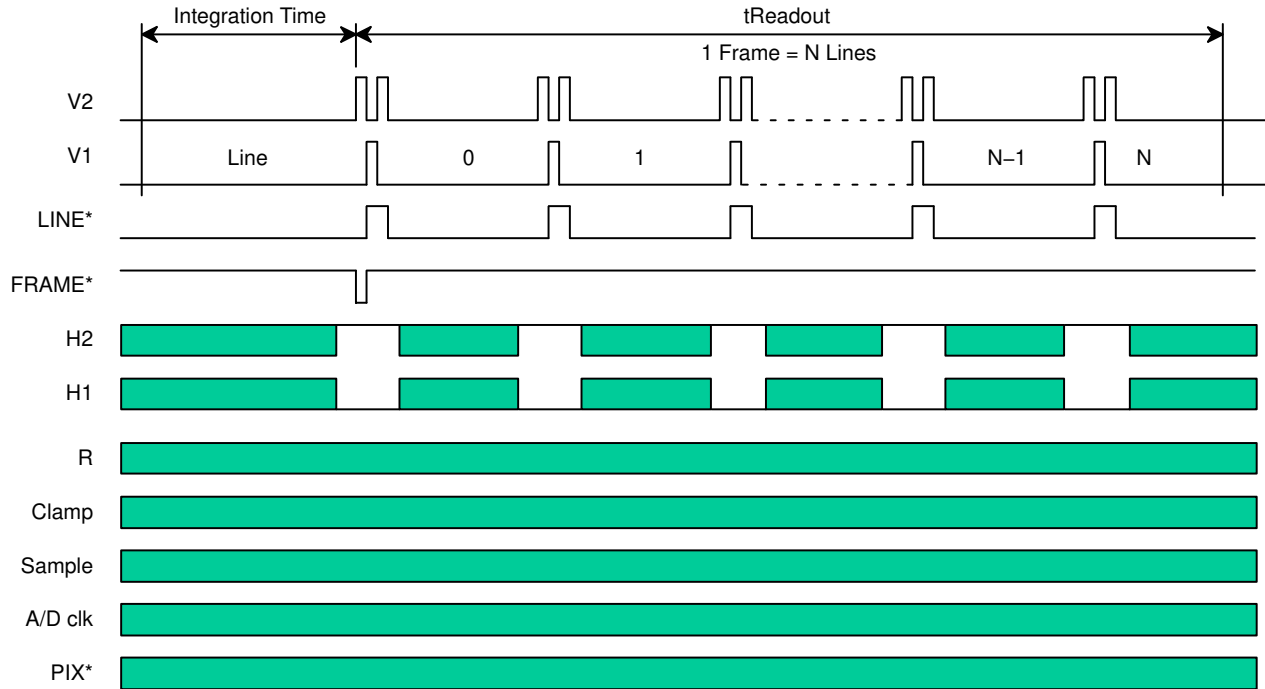


Figure 9. Frame Rate Timing for the KAF-0261, 0402, 1001, 1603, 4301, 6303, 16801

NOTE: Default Frame Grabber Settings

Frame Timing

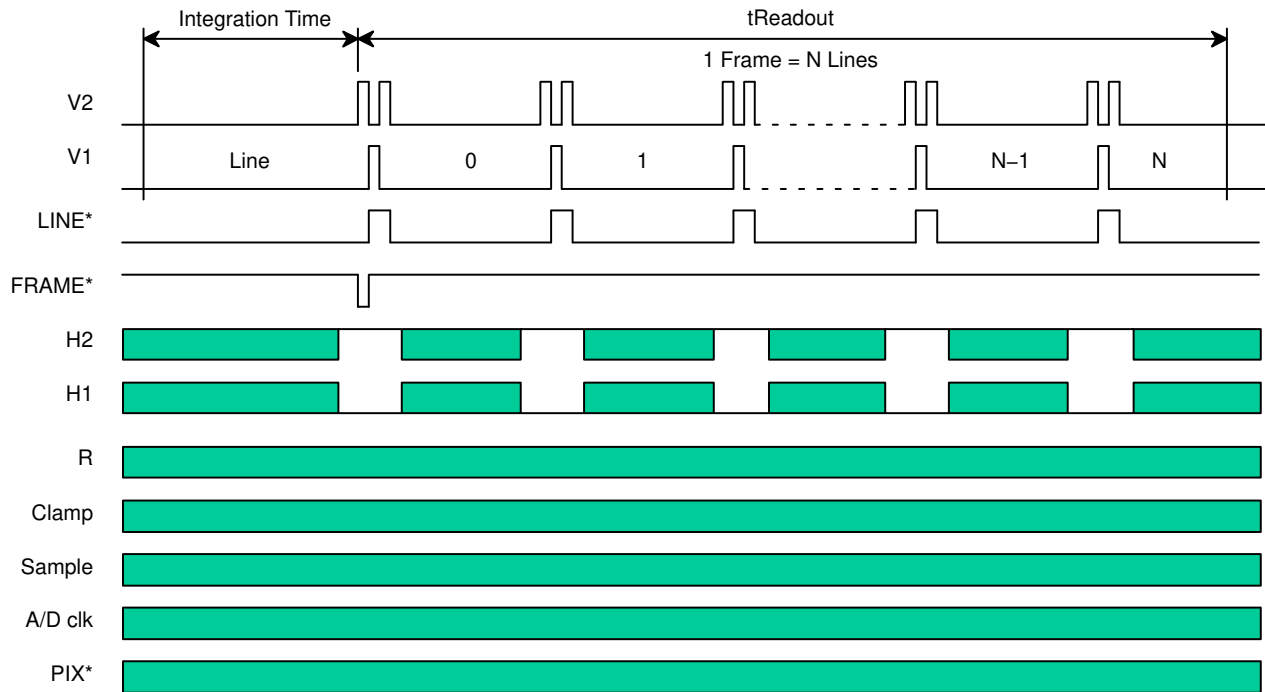


Figure 10. Frame Timing for the KAF-3200 Sensor

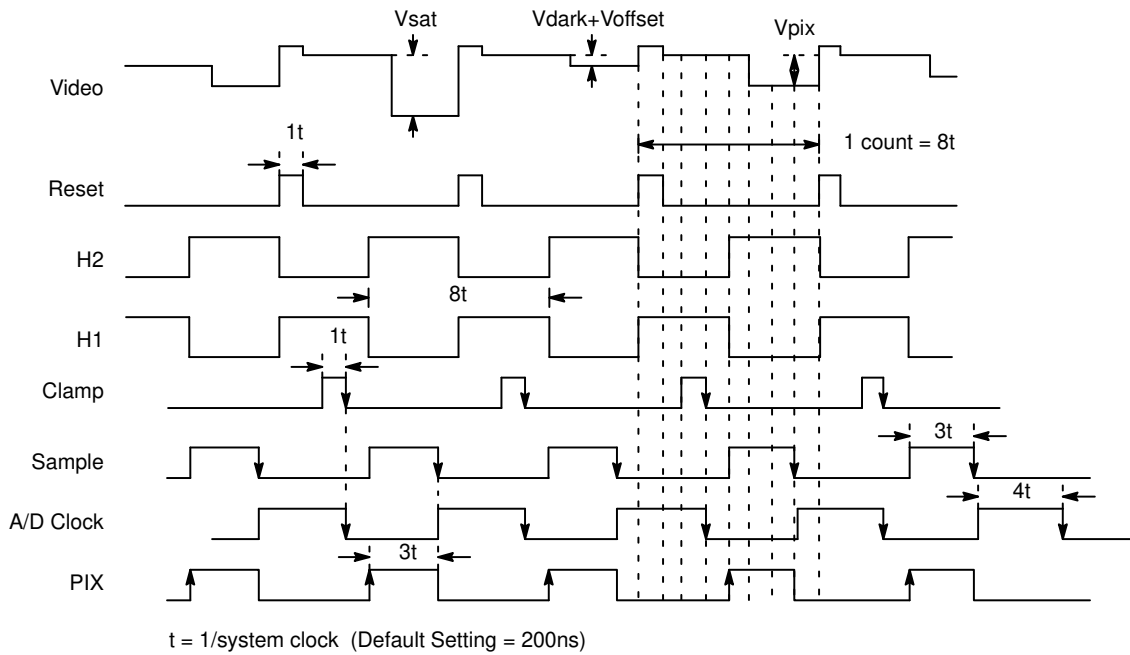


Figure 11. Pixel Rate Timing for the KAF-3200 and KAF-16801 Sensors

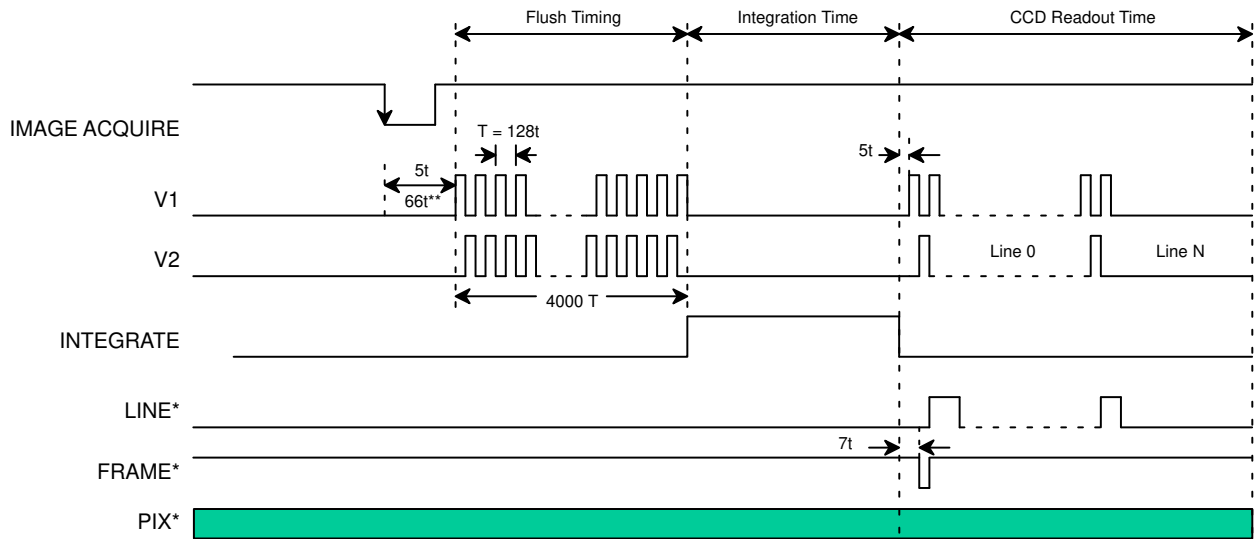


Figure 12. Still Mode: Flush and Integration Timing

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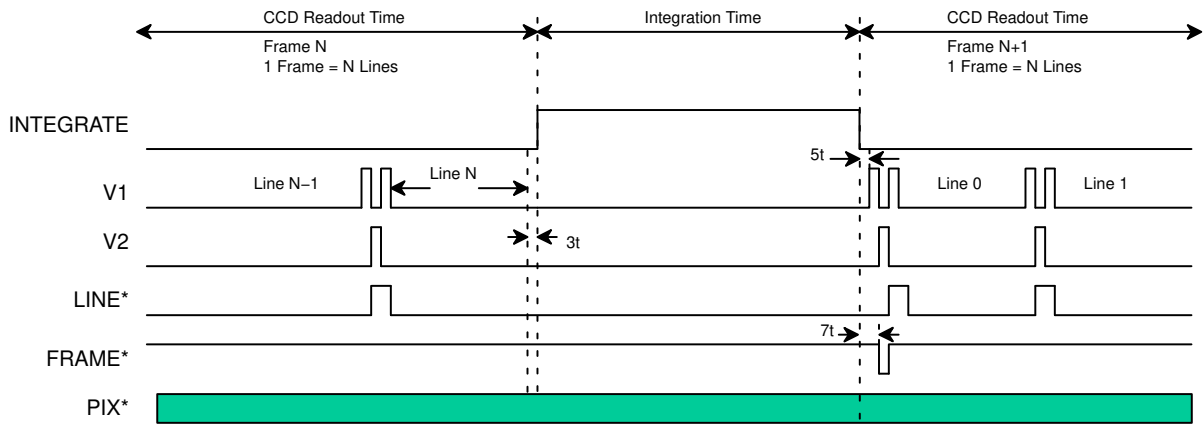
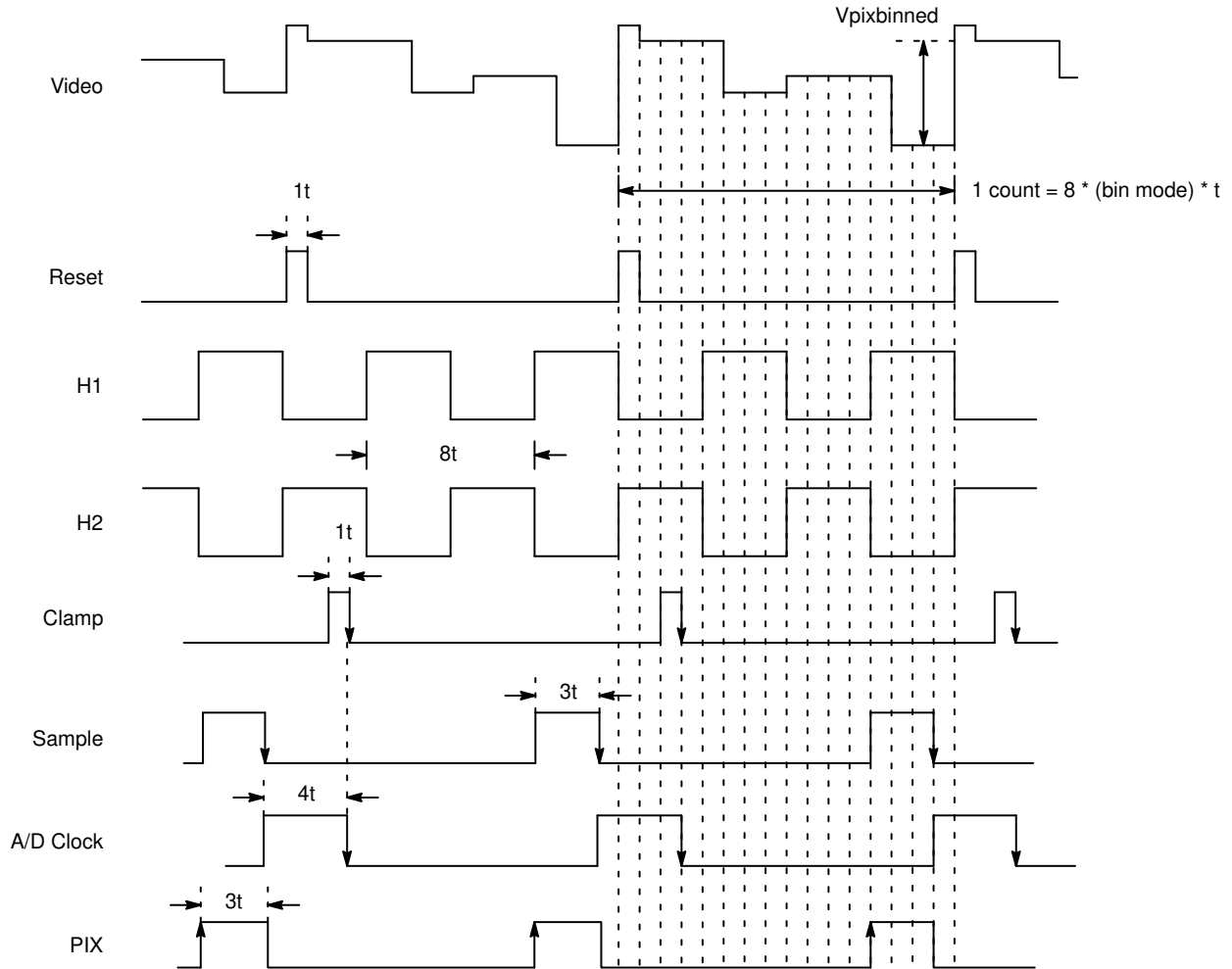


Figure 13. Free Run Mode: Integration Timing

NOTES: $t = 1/\text{system clock}$ (Default Setting = 200 ns)
 Default Frame Grabber Settings



Pixel Rate Timing

$t = 1/\text{system clock}$ (Default Setting = 200ns)

Figure 14. Binning Mode Timing (2x2 Binning Shown)

In Binning Modes, the Frequency of the Reset, Clamp, Sample, A/D, and PIX clocks are decreased in order to allow charge to accumulate on the output node of the CCD before being reset. See Application Note *Binning Mode Operation for Full Frame CCD Image Sensors* for more details on Full Frame CCD Binning.

In Binning Modes, additional lines of charge are summed in the CCD's horizontal register before being clocked to the output node.

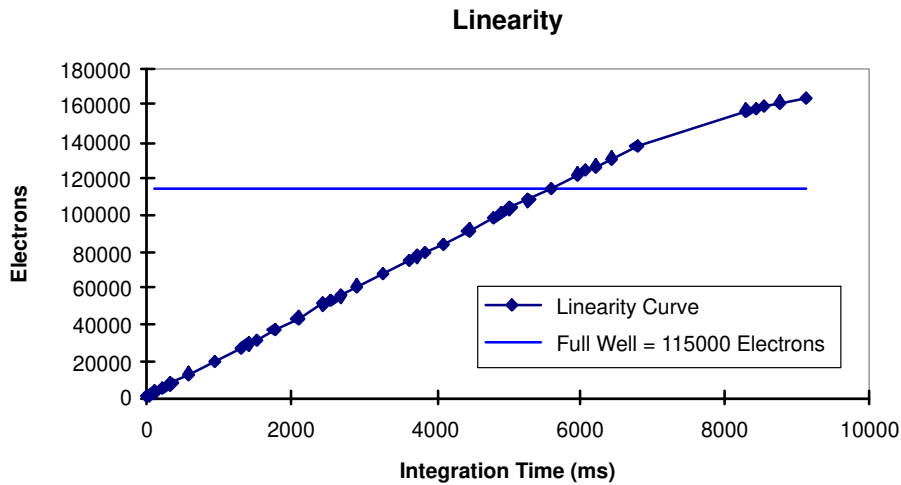
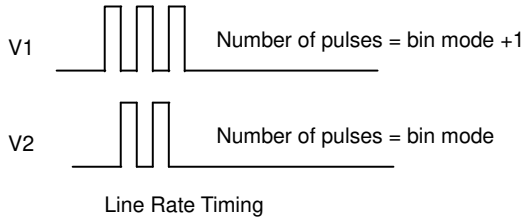


Figure 15. Measured Linearity
(Measurements Taken Using KAF-1600 Sensor)

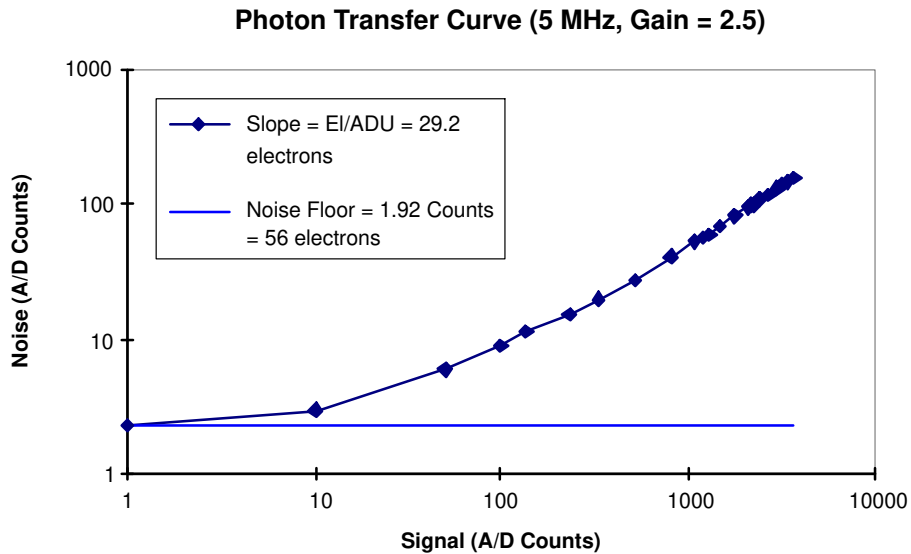


Figure 16. Measured Performance: Noise Floor
(Measurements Taken Using KAF-1600 Sensor)

System Noise Floor vs. Operating Frequency

Table 10.

Frequency (MHz)	Noise Floor (Electrons)	Dynamic Range (Bits) (Note 5)	Dynamic Range (dB) (Note 5)	EI/ADU	System Gain
1	40	11.49	69.17	29.2	2.5X
2	48	11.23	67.59	29.2	2.5X
3	50	11.17	67.23	29.2	2.5X
4	54	11.06	66.57	29.2	2.5X
5	56	11	66.25	29.2	2.5X
6	58	10.95	65.95	29.2	2.5X

5. Dynamic Range Calculated using KAF-1600 Sensor, Full Well = 115000 Electrons Measured

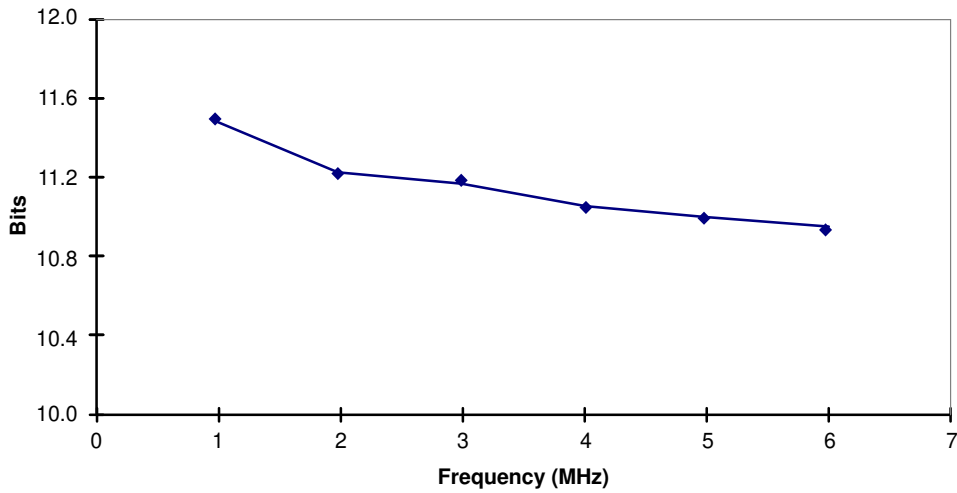
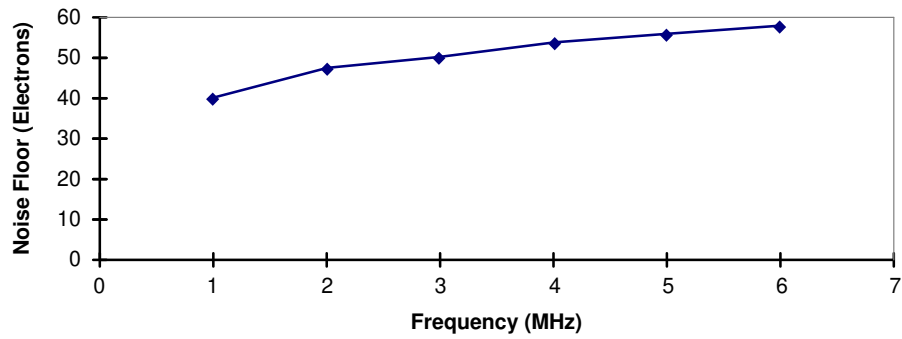
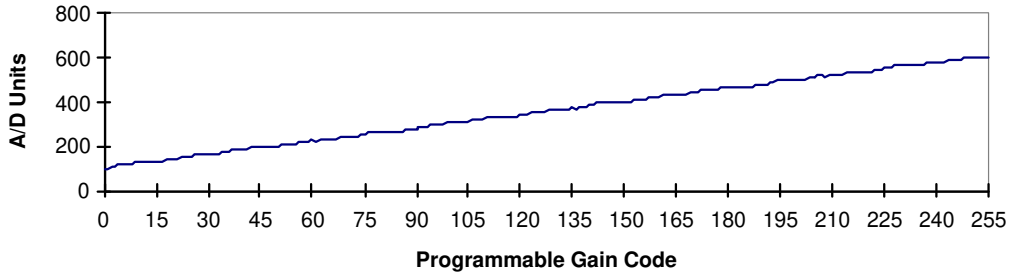


Figure 17. Measured Performance: Dynamic Range

Linearity of Programmable Analog Gain



PGA Gain

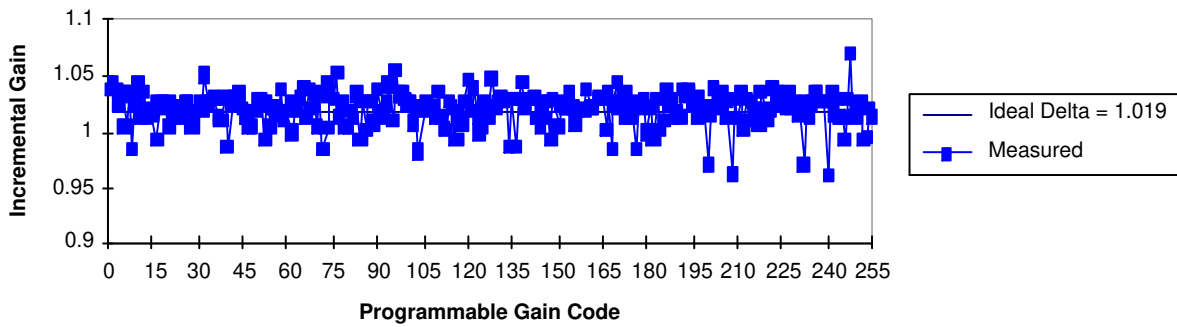
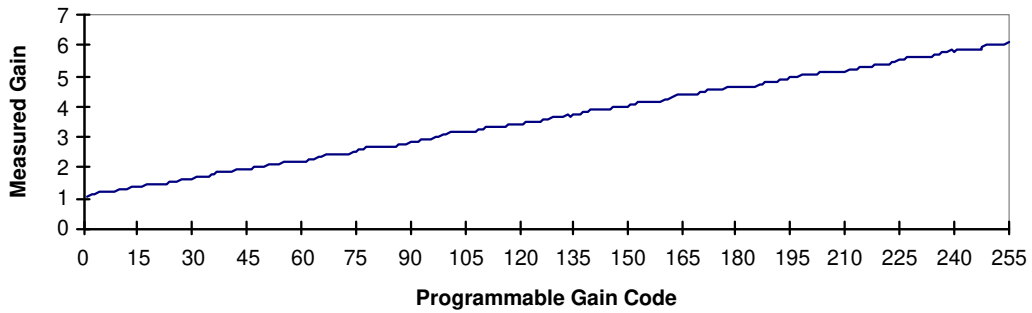


Figure 18. Measured Performance: A/D Programmable Gain

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Connector Pinouts

Table 11. IMAGER BOARD CONNECTORS J1, J2

Connector	Pin	Assignment	Connector	Pin	Assignment
J1	1	N.C.	J2	1	VSUB
J1	2	VSUB	J2	2	RESET
J1	3	N.C.	J2	3	VSUB
J1	4	VSUB	J2	4	N.C.
J1	5	N.C.	J2	5	VSUB
J1	6	VSUB	J2	6	N.C.
J1	7	VLG	J2	7	VSUB
J1	8	VSUB	J2	8	N.C.
J1	9	N.C.	J2	9	VSUB
J1	10	VSUB	J2	10	N.C.
J1	11	VDD	J2	11	VSUB
J1	12	VSUB	J2	12	H2
J1	13	VDD	J2	13	VSUB
J1	14	VSUB	J2	14	H1
J1	15	N.C.	J2	15	VSUB
J1	16	VSUB	J2	16	Video
J1	17	LOD/GUARD	J2	17	VSUB
J1	18	VSUB	J2	18	VOG
J1	19	N.C.	J2	19	VSUB
J1	20	VSUB	J2	20	VRD
J1	21	N.C.	J2	21	VSUB
J1	22	VSUB	J2	22	V2
J1	23	Neg 10 V trace	J2	23	VSUB
J1	24	VSUB	J2	24	V1

Table 12. INPUT CONNECTOR J6

Pin	Assignment	Pin	Assignment
1	INT0	2	GND
3	INT2	4	GND
5	INT3	6	GND
7	INT5	8	GND
9	IMAGE_ACQUIRE	10	GND
11	BIN0	12	GND
13	BIN1	14	GND
15	SCLOCK	16	GND
17	INT1	18	GND
19	SLOAD	20	GND
21	INT4	22	GND
23	BIN2	24	GND
25	SDATA	26	GND
27	STILL/FREE-RUN	28	GND
29	N.C.	30	GND
31	N.C.	32	GND
33	N.C.	34	GND

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Table 13. OUTPUT CONNECTOR J4

Connector	Pin	Assignment	Comment
J4	1	DIG0+	RS422
J4	2	DIG0-	RS422
J4	3	DIG1+	RS422
J4	4	DIG1-	RS422
J4	5	GND	
J4	6	DIG2+	RS422
J4	7	DIG2-	RS422
J4	8	DIG3+	RS422
J4	9	DIG3-	RS422
J4	10	GND	
J4	11	DIG4+	RS422
J4	12	DIG4-	RS422
J4	13	DIG5+	RS422
J4	14	DIG5-	RS422
J4	15	GND	
J4	16	DIG6+	RS422
J4	17	DIG6-	RS422
J4	18	DIG7+	RS422
J4	19	DIG7-	RS422
J4	20	GND	
J4	21	DIG8+	RS422
J4	22	DIG8-	RS422
J4	23	DIG9+	RS422
J4	24	DIG9-	RS422
J4	25	GND	
J4	26	DIG10+	RS422
J4	27	DIG10-	RS422
J4	28	DIG11+	RS422
J4	29	DIG11-	RS422
J4	30	GND	
J4	31	FRAME+	RS422
J4	32	FRAME-	RS422
J4	33	LINE+	RS422
J4	34	LINE-	RS422
J4	35	GND	
J4	36	PIX+	RS422
J4	37	PIX-	RS422
J4	38	N.C.	
J4	39	N.C.	
J4	40	N.C.	

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Table 14. INTEGRATE SYNC CONNECTOR J7

Connector	Pin	Assignment	Comment
J7	1	Integrate	TTL
J7	2	GND	

Table 15. POWER CONNECTOR J5

Connector	Pin	Assignment
J5	1	+18 V
J5	2	SUPPLY GND
J5	3	-18 V
J5	4	SUPPLY GND
J5	5	+5 V

Table 16. JTAG CONNECTOR J8

Connector	Pin	Assignment
J8	1	TCK
J8	2	GND
J8	3	TDO
J8	4	+5 V
J8	5	TMS
J8	6	N.C.
J8	7	N.C.
J8	8	N.C.
J8	9	TDI
J8	10	GND

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When programming the Timing Board, the Imager Board must be disconnected from the Timing Board before power is applied. If the Imager Board is connected to the Timing

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REFERENCES

[1] KAF-0261, KAF-0402, KAF-1001, KAF-1603, KAF-3200, KAF-6303, KAF-16801, and KAF-4301 Device Specifications

[2] Full Frame Evaluation Kit Schematics
[3] Analog Devices AD9816 Product Data Sheet

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