MityCAM-C8000 User's Manual

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1 Introduction

The purpose of this document is to detail features of the MityCAM-C8000.

1.1 Additional Documentation

In addition to this document, the following documents are also useful / pertinent to the use and operation of the MityCAM-C8000 cameras.

Table 1: Reference Documentation

Document #	Title	Description
60-000003	MityCAM-C8000 datasheet	Complete specification for MityCAM-C8000.
60-000006	MityCAM-C8000 Camera Link Interface	Defines Application programmers interface for serial interface of MityCAM-C8000 Camera Link port.
P-10281	MityCAM Firmware Upgrade Procedure	Describes steps to upgrade MityCAM-C8000 camera firmware.
AIA GigE Vision	GigE Vision Version 2.0	AIA GigE Video streaming and device control over Ethernet Standard. Version 2.0.

1.2 Vocabulary

Sensor – The CMV sensor on the headboard of the hardware stack.

SCLK – The master clock input to the sensor. This dictates data rates out of the sensor and into the processing pipeline.

MCLK – A reference clock frequency that directly corresponds to the configured SCLK. This is the clock used to define exposure time, frame interval time, etc.

1.3 Organization

This document is organized in sections covering a specific topic (such as Burst Mode Operation or Continuous High Speed Operation) and subsections for a particular interface configuration. Each subsection provides a set of commands to be executed to enter a particular mode with a table like the one that follows.

Table 2: Command Profile Format for User Manual

Step	Command	Comment
Num	<CMD>	Explanation of the command

2 Exposure Time

Exposure can be performed both internally on the sensor and externally. Depending on the chosen method, the resolution, minimum and maximum exposures change. In the following sections, CLK_PERIOD is 1/MCLK. MCLK and the corresponding CLK_PERIOD are listed in section #5 "Changing SCLK."

2.1 Internal Exposure

Due to sensor recommended register values, the following table holds for internally controlled exposure times.

Table 3: Internal Exposure Range

Min	Max	Resolution
2147*CLK_PERIOD	1895827329*CLK_PERIOD	113*CLK_PERIOD

2.2 External Exposure

The MityCAM-C8000 allows exposure to be controlled external to the sensor. In order to use external exposure control, external frame triggering must also be provided. See Section 9.1.2 for details.

Table 4: External Exposure Range

Min	Max	Resolution
1*CLK_PERIOD	-	CLK_PERIOD

3 Frame Interval

Frame interval times using internal triggering is shown in Table 5. In the table, FOT stands for "Frame Overhead Time" and "readout" is the sensor readout time. Frames may also be externally triggering, in which case the maximum frame interval table is not restricted. It should be noted that, for continuous operation, the realizable shortest frame interval time is generally limited by the output interface selected (e.g., dual Camera Link vs. Gigabit Ethernet). See the MityCAM-C8000 datasheet for maximum output interface rates.

Table 5: Legal Frame Interval Times

Min	Max	Resolution
FOT + MAX(Readout, Exposure)	2147483647*CLK_PERIOD	CLK_PERIOD

For 10 bit readout and the case where the CLK_PERIOD corresponds to 150 MHz, the FOT is 391.17 µs and the sensor readout time is NUM_ROWS x 7.53 µs. For the case where the CLK_PERIOD Is 300 MHz, the FOT is 196.08 µs and the sensor readout time is NUM_ROWS x 3.77 µs.

4 Continuous High Speed Operation

This section details setting up full resolution, high speed operation in each Camera Link configuration. Pay careful attention to the clock and frame intervals that are being set. Failure to set an appropriate clock or frame interval will overflow the FPGA with sensor data resulting in undefined output.

4.1 Camera Link

4.1.1 Expanded 8-bit Mode (8 bit x 10 pixels)

This mode offers the highest continuous frame-rate possible.

Table 6: Camera Link Command Sequence for 8-bit Mode, 10-tap Output

Step	Command	Comment
1	<SOMD 0>	Go to expanded Camera Link output
2	<SBPP 0>	Go to 8 bpp output
3	<SCLK 7>	Set the master clock to mode 7 (IN_LCLK = 275MHz)
4	<SFIT 0>	Set the frame-rate to the maximum supported
5	<STRT>	Begin continuously capturing

The camera will now be outputting at 95fps.

4.1.2 Expanded 16-bit Mode (16 bit x 5 pixels)

This mode offers the highest continuous frame-rate possible while outputting all of the sensor data.

Table 7: Camera Link Command Sequence for 16-bit Mode, 10-tap Output

Step	Command	Comment
1	<SOMD 0>	Go to expanded Camera Link output
2	<SBPP 1>	Go to 16 bpp output
3	<SCLK 2>	Set the master clock to mode 2 (IN_LCLK = 137.5MHz)
4	<SFIT 0>	Set the frame-rate to the maximum supported
5	<STRT>	Begin continuously capturing

The camera will now be outputting at 47.5 fps.

4.1.3 Base 8-bit Mode (8 bit x 2 pixels)

This mode offers the highest continuous frame-rate possible.

Table 8: Camera Link Command Sequence for Base Mode 2 x 8 bpp

Step	Command	Comment
1	<SOMD 1>	Go to Base Camera Link output
2	<SBPP 0>	Go to 8 bpp output
3	<SFIT 50000>	Set the frame-rate to 20 fps
4	<STRT>	Begin continuously capturing

The camera will now be outputting at 20 fps.

Note that it does not matter which clock is used in this mode. Further, note that the frame-rate must be explicitly limited to 20 fps or slower.

4.1.4 Base 16-bit Mode (16 bit x 1 pixel)

This mode offers the highest continuous frame-rate possible.

Table 9: Camera Link Command Sequence for Base Mode 16 bpp

Step	Command	Comment
1	<SOMD 1>	Go to Base Camera Link output
2	<SBPP 1>	Go to 16 bpp output
3	<SFIT 100000>	Set the frame-rate to 10 fps
4	<STRT>	Begin continuously capturing

The camera will now be outputting at 10 fps.
Note that it does not matter which clock is used in this mode. Further, note that the frame-rate must be explicitly limited to 10 fps or slower.

4.1.5 Base 12-bit Mode (12 bit x 2 pixels)

This mode offers the highest continuous frame-rate possible.

Table 10: Camera Link Command for Base Mode 2 x 12 bpp

Step	Command	Comment
1	<SOMD 1>	Go to Base Camera Link output
2	<SBPP 2>	Go to 12 bpp output
3	<SFIT 50000>	Set the frame-rate to 20 fps
4	<STRT>	Begin continuously capturing

The camera will now be outputting at 20 fps.

Note that it does not matter which clock is used in this mode. Further, note that the frame-rate must be explicitly limited to 20 fps or slower.

4.2 AIA GigE Protocol

Continuous operation for AIA GigE should be achieved using the GenICAM compliant standard format naming convention (SFNC) registers. The AIA GigE implementation supports 8, 12, and 16 bit per pixel output formats.

4.3 MityViewer

By default, the camera will be running with maximum SCLK. SCLK is not configurable from MityViewer. Frames will be dropped internally to the camera should the capture rate exceed the link's capabilities. To enable continuous capture, check the "continuous" box. See Figure 1.
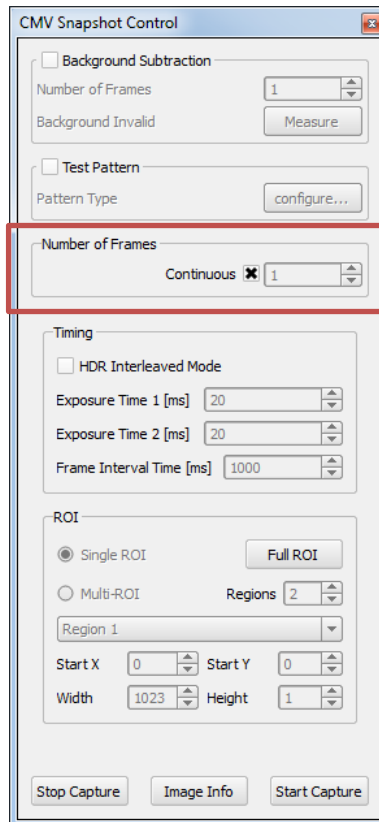
Figure 1: Continuous Capture Selection

4.4 Notes

4.4.1 Capture Cards

At full resolution, the high speed continuous operation can cause some frame grabbers to overflow. If this is frequently occurring, or if the frame grabber is unable to capture video at the rate it is being output, try reducing the frame rate by increasing the frame interval time using the <SFIT> command. If the problem continues, the master clock can be decreased to further reduce the data rate.

5 Changing SCLK

Changing SCLK is necessary to achieve lower data rates that Camera Link can handle, as well as modifying the precision and values associated with exposure and frame interval.

Valid IN_LCLK values can be set to the following:

Table 11: Allowed SCLK Rates

Setting	Clock Frequency SCLK (MHz)	MCLK (MHz)	MCLK Period (ns)
1	125	25	40
2	137.5	27.5	36.3
3	150	30	33.3
4	180	36	27.8
5	200	40	25
6	250	50	20
7	275	55	18.2
8	300	60	16.7

Modifying SCLK is necessary to reduce the data rate coming out of the sensor to facilitate certain Camera Link modes or to extend exposure time.

6 Burst Mode Operation

6.1 Camera Link

The camera has a section of RAM dedicated as a circular image buffer. This allows the camera to capture up to 42 images at a speed faster than Camera Link allows. When the capture is complete, the data will be output over Camera Link (in whatever the current configuration is) at approximately 10 frames per second. To use burst mode, configure the camera's ROI and capture rate.

Table 12: Burst Capture Command

Step	Command	Comment
1	<STRT 30>	Start a burst capture of 30 frames

Output of the frames will not begin until the entire capture has been completed. The output will be approximately 10 frames per second regardless of the actual capture rate.

6.2 AIA GigE Protocol

Burst mode is currently not supported using the AIA GigE protocol.

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6.3 MityViewer

To perform a burst capture, uncheck "Continuous" and select the number of frames to burst. Then select "Start Capture." The requisite number of frames will be captured and streamed to MityViewer. In this mode, no frames are dropped on the camera. See Figure 2.
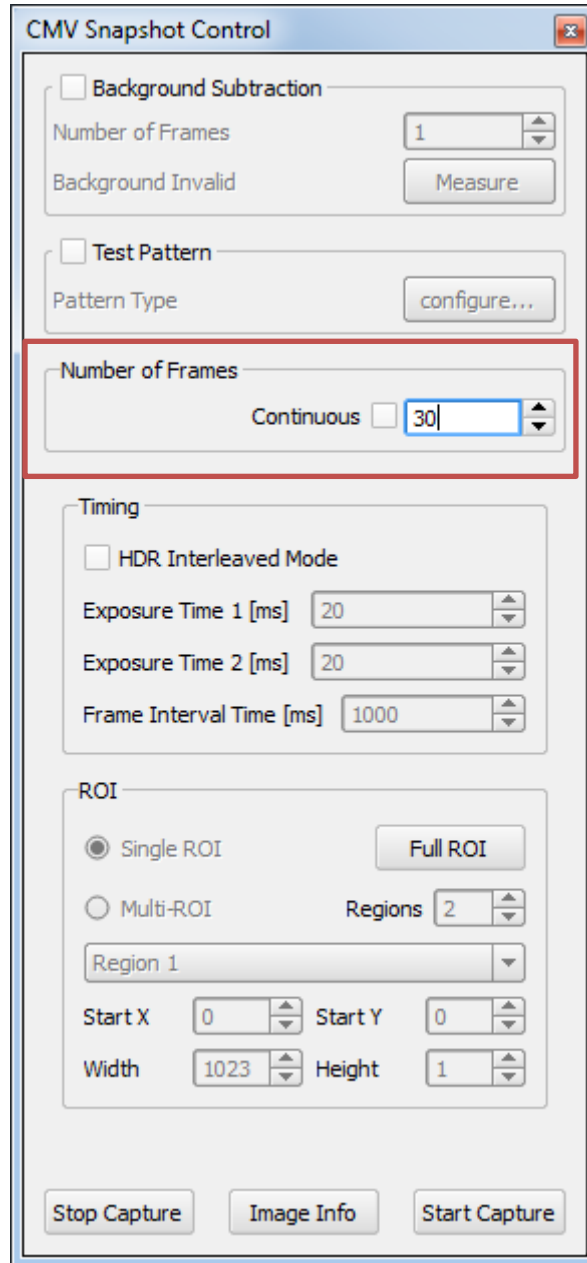

Figure 2: Burst Capture Selection

6.4 Notes

The maximum size of a burst is 42 frames. Requests for more frames will result in undefined behavior. Any clock and output configuration can be used. The output frame rate is not configurable at this time.

7 Configurable Region(s) of Interest

This section details the Multiple ROI features of the CMV8000. As a pre-requisite, the camera should be placed in a stopped state, by issuing <STOP>, prior to setting a new ROI.

There are a few limitations of Multiple ROI mode which will be discussed here. Figure 3 below shows 3 images with multiple ROI. Set 1 and 2 contain configurations which are not possible. Set 3 displays a configuration which is valid.
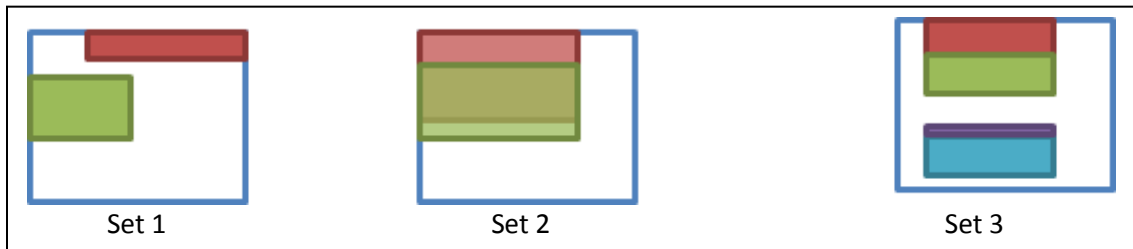
Figure 3: Configurable Regions on Interest

One limitation is the width of each region must be equal; each region must have the same width as window 0. Further, each region must also start at the same column as window 0. For these reasons, Set 1 is not a possible configuration.

Another limitation is that windows cannot overlap. For this reason, Set 2 is not a valid configuration.
Set 3 is valid because all 4 regions are the same width and start on the same column. Further, none of the regions overlap.

Up to 8 separate windows can be used.

7.1 Camera Link

7.1.1 1 Region of Interest

In many cases, multiple ROIs are not needed. To set a single ROI use the following set of operations. This example places the camera into a full resolution state with a single ROI.

Table 13: Camera Link Commands to Configure Multiple ROIs

Step	Command	Comment
1	<NROI 1>	Disable Multi-ROI mode (set the number of regions to 1)
2	<SROI 0 0 3360 2496>	Go to full resolution (3360x2496).

The camera will now be configured to output full resolution imagery.

7.1.2 3 Regions of Interest

This will configure the camera to read three windows (see Figure 4). It also demonstrates that the windows do not have to be consecutive in nature.
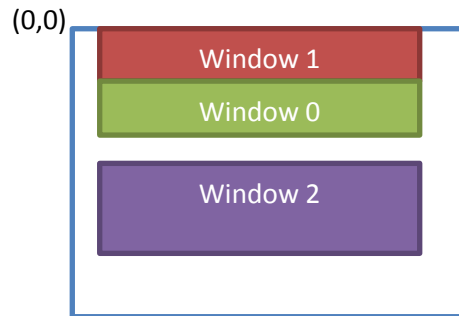

Figure 4: Example Configuration of 3 ROIs

Table 14: Camera Link Commands to Configure Example 3 Region ROI

Step	Command	Comment
1	<NROI 3>	Enable Multi-ROI mode (set the number of regions to 3)
2	<MROI 0 50 300 2000 300>	Set window 0 to be 2000x300 starting at (50, 300)
3	<MROI 1 50 0 2000 300>	Set window 1 to be 2000x300 starting at (50, 0)
4	<MROI 2 50 1496 2000 1000>	Set window 2 to be 2000x1000 starting at (50, 1496)

The resulting images will consist of each window in order from 0 to N-1 where N is the number of regions selected. The start column and width of the image will be that of window 0. For the above example, the output will be:
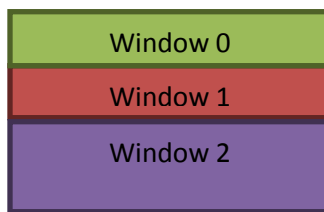
Figure 5: Resulting Image from Multi-ROI Example

At a total output resolution of 2000x1600 will result.

7.2 AIA GigE Protocol

Multi-ROI mode is currently not supported for the AIA GigE Protocol. For single ROI, configure the GenICam defined Width, Height, OffsetX, and OffsetY registers while IDLE.

7.3 MityViewer

MityViewer provides an input box for modifying the region of interest and multiple ROI on the "CMV Snapshot Control." See Figure 6 Region of Interest Configuration Box.

By default, the camera is in Single ROI mode.

To enter Multi-ROI mode, select the radial button next to the "Multi-ROI" label. Select the number of regions from within the "Regions" box. The number of regions is limited between 2 and 8.

Set the start Y and Height for each region by selecting the region in the drop down menu, then editing the desired parameters. Region 1 dictates the entire image's Start X and Width parameters.

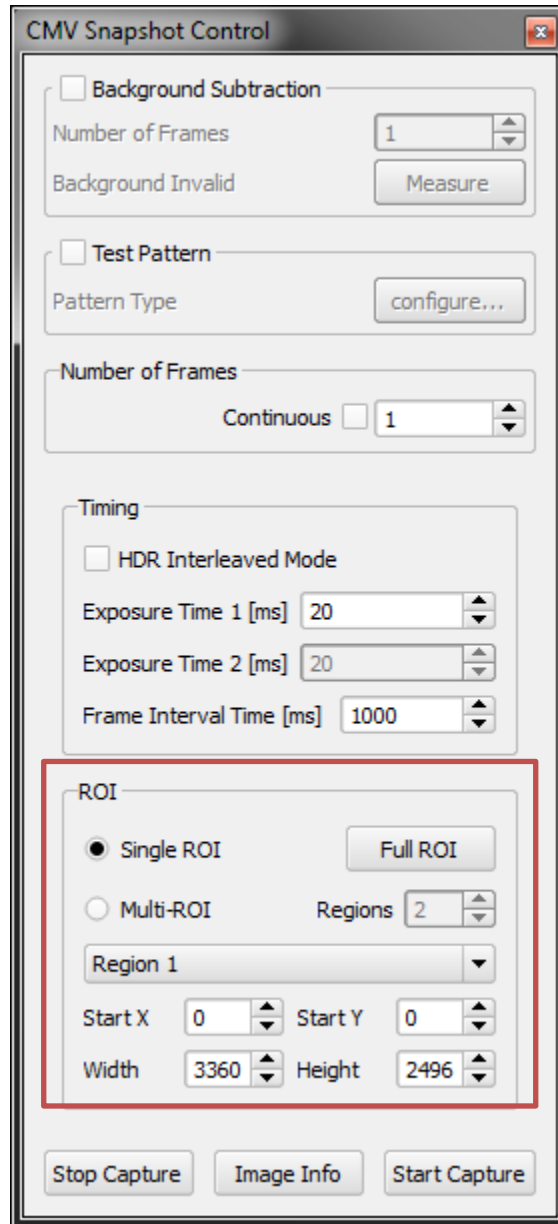**Figure 6: Region of Interest Configuration Box**

MityViewer prevents ROIs from starting before the previous ROI ends (that is, each window must be in order from top to bottom). For a given region N, region N+1 must have a Start Y that is equal to or greater than the previous regions Start Y. + Height.

7.4 Notes

Because the sensor outputs entire rows regardless of the configuration, decreasing the horizontal ROI has no effect on the frame rate. If an ROI like that pictured in Figure 7 is desired, a windowed ROI could be used with the extra data being discarded or ignored after it has been captured from the camera.

Get   by requesting   then discarding

Figure 7: Creating Unique ROIs

8 GPIOs

There are 4 general purpose IOs that can be used. The available modes of operation for them are listed in Table 15.

Table 15: GPIO Modes

#	Mode
1.	Input for reading
2.	Output driven low
3.	Output driven high
4.	Input for external trigger (See section # 9 "External Triggering")

This section will cover Modes 1, 2 and 3. Mode 4 is covered in separate sections.

All inputs/outputs are TTL 5V logic.

8.1 Input

In the input mode of operation, the pin can be queried for its current logical value (High or Low).

8.1.1 Camera Link

Issue <GETP>. The result will be a hex value representing each pin value, as a bit-mask, which was read back. Each bit represents the IO it belongs to (Bit 2 → IO 2's state).

For example, if the response is <ACK><A>, then IO 0 and IO 2 are presently low; IO 1 and IO 3 are presently high.

8.1.2 AIA GigE Protocol

The AIA GigE support for reading the GPIOs will be defined in the GenICam SFNC digital IO control registers.

8.1.3 MityViewer

To place a pin in Input mode, select "In" from the drop down selection box. As shown in Figure 8

To read back the current state, press "Update." Pins which are being driven high are denoted with an "x" pins which are low are left blank.
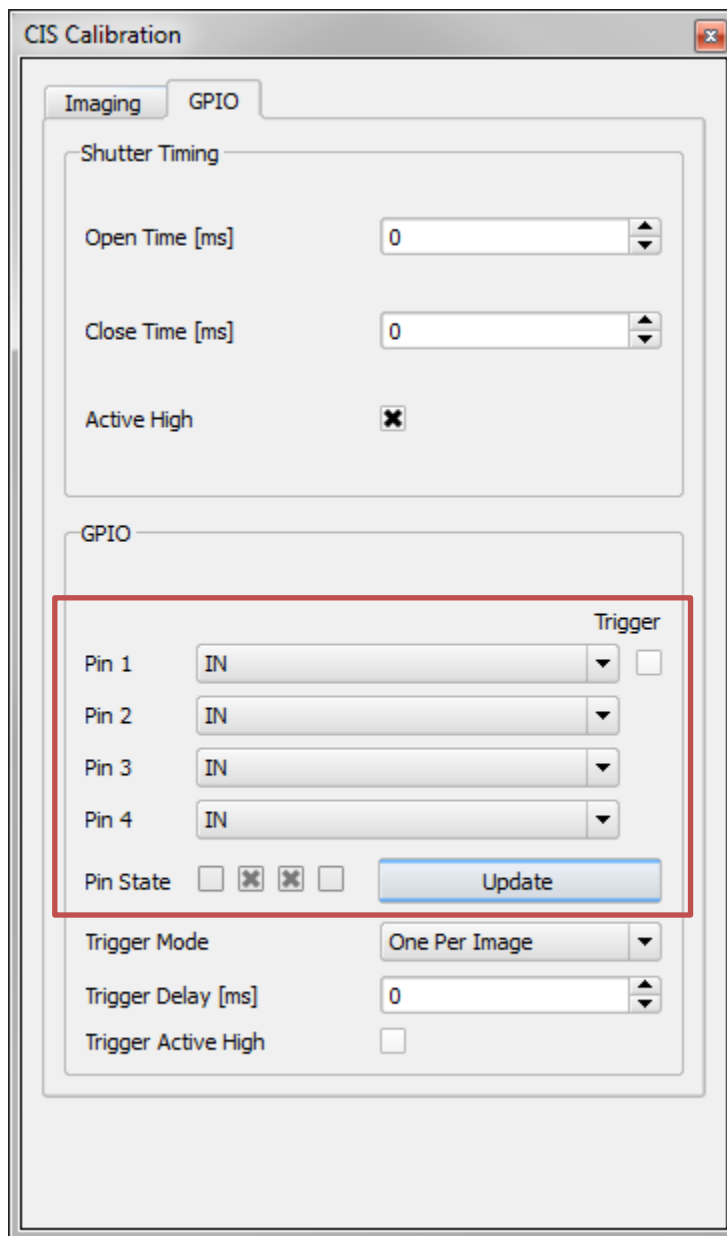
Figure 8: Update GPIO Pin States

From left to right, the state is reported as Pin 1, Pin 2, Pin 3 and Pin 4.

8.2 Output

In output mode, the pin can be driven high or low. This can be used to toggle a light source or some other operation. See Table 16.

8.2.1 Camera Link

Issue the following commands to drive a pin to high/low:

Table 16: Camera Link Commands for Configuring GPIO pins

#	Command	Meaning
1	<SETD N 1>	Set the pin direction of IO N to 1 (output)
2	<SETP N 1/0>	Drive IO N to logic 1 (high) or logic 0 (low)

8.2.2 AIA GigE Protocol

The AIA GigE support for reading the GPIOs will be defined in the GenICam SFNC digital IO control registers.

8.2.3 MityViewer

To drive an output high or low, select the "High" or "Low" options in the pin selection drop down. The pin will be immediately requested to that state.

9 External Triggering

The GPIOs on the camera can be driven/queried using the SETD, SETP, GETD and GETP commands. Further, the camera can be configured such that it is externally triggered to capture via select GPIOs. The camera can also be configured for either internal exposure or external exposure through a second GPIO. For the MityCAM-C8000, CamIO 0 is available for triggering the FRAME_REQ pin on the sensor, and CamIO 1 is available for triggering the INT1 pin of the sensor.

Figure 9 illustrates the maximum frame rate that is limited by the sensor readout. Typically, the sensor readout is faster than the link readout rate (notionally shown on the bottom two traces), and so this mode is also referred to as Burst Mode. The MityCAM-C8000 supports buffering up to 40 frames in internal memory to support capturing a burst of frames for readout. When in external trigger mode (with internal exposure control), the CamIO 0 pulse initiates exposure time as shown in the figure. This signal is generated internally when in internal trigger mode.

In burst mode captures, an exposure can be initiated during sensor readout, as long as the exposure does not complete until the previous sensor readout completes. This figure is not drawn to scale. The sensor frame overhead time (FOT) and readout times are described in Section 3, and for 3360 x 2496 sized ROIs at 150 MHz CLK rates are 392 and 18,803 µs, respectively. For Gigabit Ethernet at 12 bits per pixel, the frame transfer time is 134 ms.
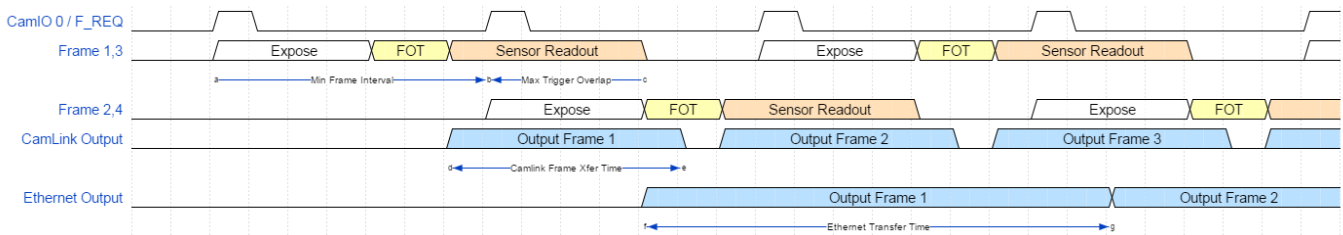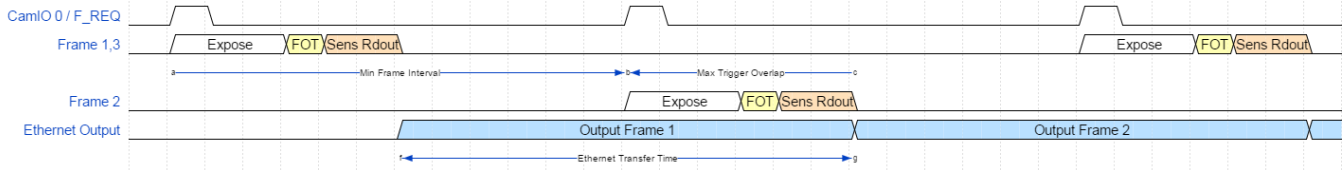

Figure 9: Sensor Readout Timing, External Trigger, Internal Exposure Control, Burst Mode (Sensor Limited)
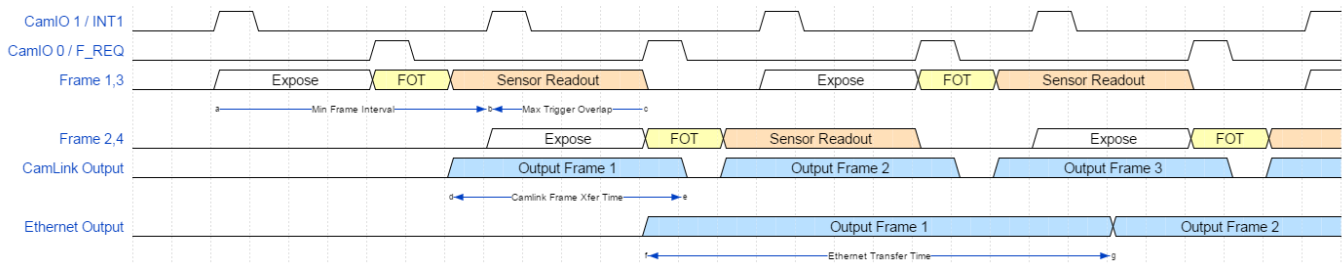
Figure 10 illustrates the maximum frame rate for continuous capture. Typically, continuous capture frame rates are limited by the link transfer time. The Ethernet output transfer time has been shown in this figure.
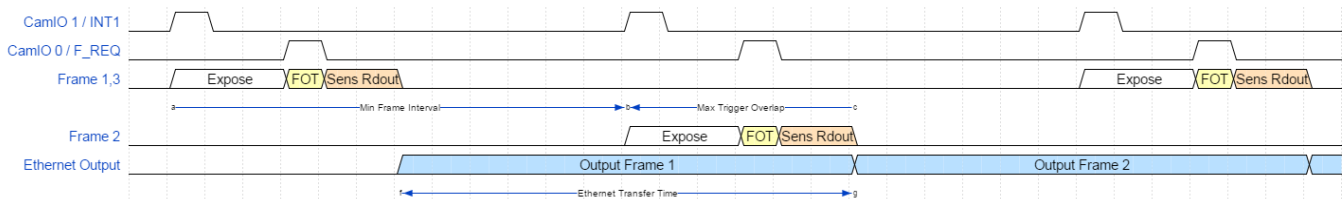

Figure 10: Sensor Readout Timing, External Trigger, Internal Exposure Control, Continuous Mode (IO Link Limited)

Figure 11 illustrates the maximum frame rate that is limited by the sensor readout (burst mode) when using external exposure and trigger control. In this case, the exposure start is initiated by pulsing CAMIO 1, and the exposure is ended by pulsing CAMIO 0. When CAMIO 0 is pulsed, the frame begins readout. All other timing constraints are the same as those shown in Figure 9.

Figure 11: Sensor Readout Timing, External Trigger, External Exposure Control, Burst Mode (Sensor Limited)

Figure 12 illustrates the maximum frame rate for continuous output (limited by IO link rates) when using external exposure and trigger control. In this case, the exposure start is initiated by pulsing CAMIO 1, and the exposure is ended by pulsing CAMIO 0. When CAMIO 0 is pulsed, the frame begins readout. All other timing constraints are the same as those shown in Figure 10.

Figure 12: Sensor Readout Timing, External Trigger, External Exposure Control, Continuous Mode (IO Link Limited)

Please reference the CMV8000 datasheet for the sensor for detailed timing information.

9.1 Camera Link

9.1.1 External Trigger with Internal Exposure

This example will setup and arm the camera for an external capture with an exposure time of 10ms. It will also set up to output in expanded 8-bit output. See Table 17.

Table 17: Example Camera Link Command for External Trigger with Internal Exposure

Step	Command	Comment
1	<SOMD 0>	Go to expanded Camera Link output
2	<SBPP 0>	Go to 8 bpp output
3	<SCLK 7>	Set the master clock to mode 7 (IN_LCLK = 275MHz)
4	<SEXP 10000>	Set the exposure time to be 10ms
5	<TRIG 1>	Arm the camera for external triggering
6	<EXPM 0>	Set internal exposure mode
7	<STRT>	Arm the camera for capturing

The camera is now armed and will capture a 10ms exposed image on each rising edge applied to CamIO 0.

9.1.2 External Trigger with External Exposure

This example will setup and arm the camera for an external capture with an externally defined exposure time. It will also set up to output in expanded 8-bit output. See Table 18.

Table 18: Example Camera Link Command for External Trigger with External Exposure

Step	Command	Comment
1	<SOMD 0>	Go to expanded Camera Link output
2	<SBPP 0>	Go to 8 bpp output
3	<SCLK 7>	Set the master clock to mode 7 (IN_LCLK = 275MHz)
4	<TRIG 1>	Arm the camera for external triggering
5	<EXPM 1>	Set external exposure mode
6	<STRT>	Arm the camera for capturing

The camera is now armed and will begin exposure on the rising edge of CamIO 1. Exposure will end, and the frame will be output on the rising edge of CamIO 0.

9.2 AIA GigE Protocol

The AIA GigE support for external trigger will be defined in the GenICam SFNC trigger control registers.

9.3 MityViewer

MityViewer is capable of performing external trigger with internal exposure only. Set exposure to the desired exposure time.

On the GPIO tab of the CMV Calibration Window, set Pin 1 to input and press the checkbox:
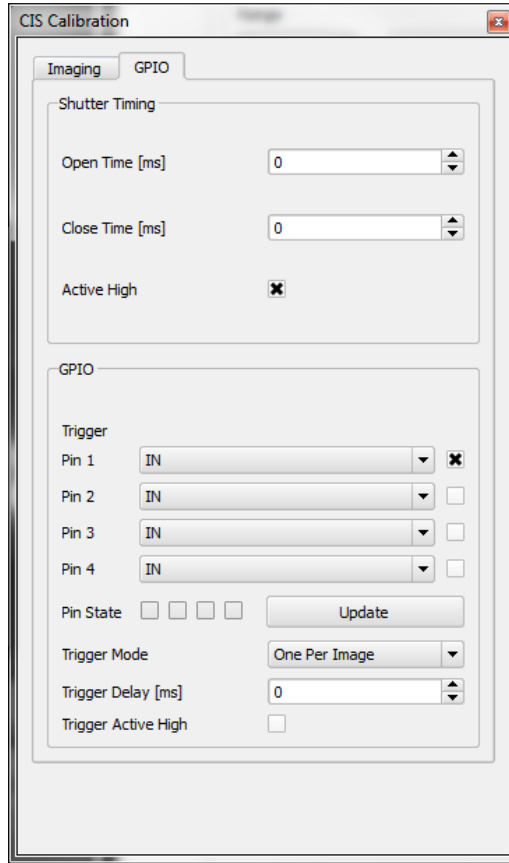
Figure 13: MityViewer CIS Calibration Window Configured for External Trigger
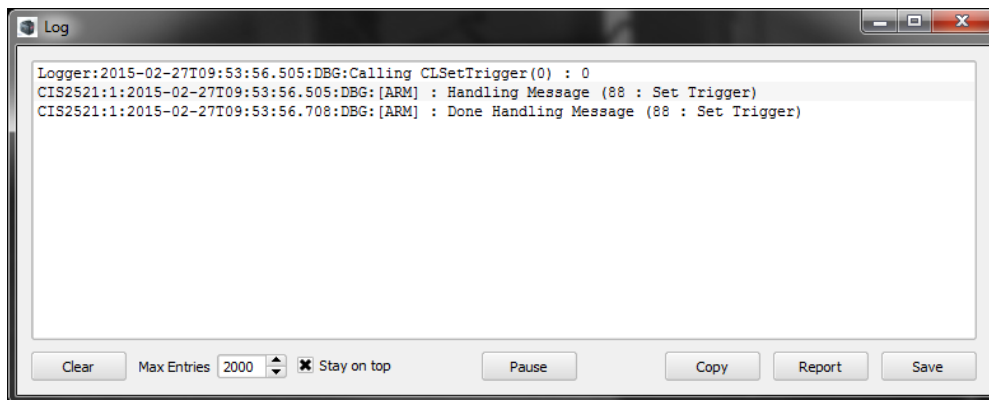
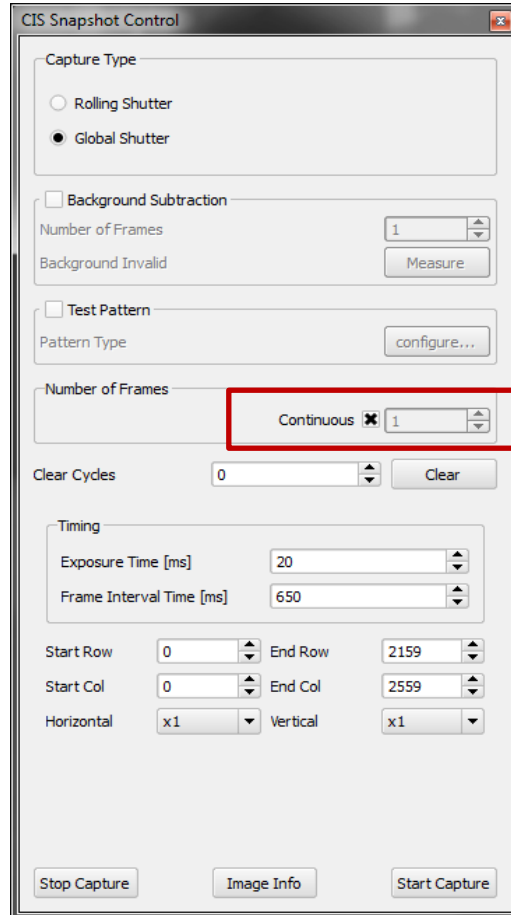In the log, the following lines will appear:

Figure 14: MityViewer Log Window for Trigger Configuration

On the Snapshot Control, select Continuous, and set the desired exposure time. Frame interval is ignored when in external trigger mode:

Figure 15: MityViewer Snapshot Control Window, Configure for Continuous Capture

Select "Start Capture" to arm the camera. Applying external triggers will begin updating the frame.

To exit external trigger mode, click "Stop Capture," then deselect the trigger checkbox.

9.4 Notes

The frame rate for external triggering cannot exceed the maximum frame rates in continuous capture modes. The master input clock must also be set appropriately for the bit-depth being output (SCLK 2 for 16 bit output and SCLK 7 for 8 bit output) when in expanded output mode. Care should be taken to ensure the frame-rate does not exceed the maximums of those found in continuous capture mode.

10 Network Configuration

There are 2 TCP/IP (IPV4) network interfaces currently used by the MityCAM-C8000, namely USB and Gigabit Ethernet. For all I/O options, a USB2.0 port is available that runs the Remote Network Driver Interface Specification (RNDIS) with a fixed, static IP address configured from the factory. For cameras with the Gigabit-Ethernet interface option, the IPV4 address is configured at the factory to use the Dynamic Host Configuration Protocol (DHCP) and the Auto IP (AOIP) protocol as defined in the AIA GigE standard.

Table 19: Factory Default Network Address Settings

Interface	DHCP?	IPV4 Address / netmask
USB 2.0 Port	N	10.1.47.2/16
Gigabit Ethernet (option)	Y	N/A

There is a mechanism for updating the default network address via a simple web page interface to the camera. The MityViewer application, which uses the Critical Link *clcamiface* DLL, provides a mechanism to locate the device on the network using a custom discovery protocol. You can locate an Ethernet camera connection by selecting "Ethernet" and "Scan for devices" on the camera connection dialog of the application.

Using either the USB 2.0 Port or the Gigabit Ethernet interface, you can alter the network configuration of either interface by opening a standard Web Browser (e.g., Internet Explorer, Chrome, Firefox, etc.) and connection to address http://10.1.47.2/netconfig.py. Change the 10.1.47.2 address to the appropriate address if you are using the Gigabit Ethernet interface. After selecting this web-page, you should see the following dialog:
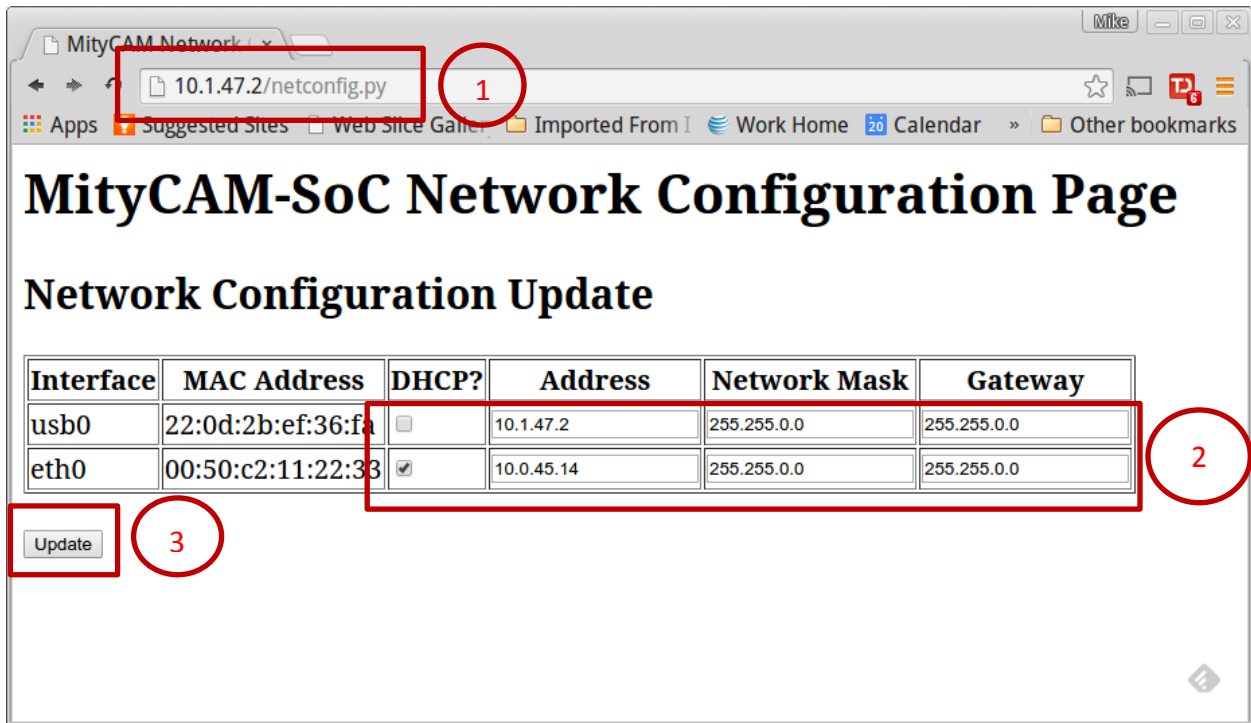

Figure 16: Network Configuration Web page

With the displayed dialog, change the network settings for the interface that needs updating and select the "update" button. This will cause the device to rewrite its network configuration settings and restart the network connections immediately. Note: if you are modifying the same network interface that you are connected on, you may need to power cycle the camera after 1 minute to reconnect the network web interface.

11 Firmware Upgrade

Recent versions of the MityCAM-C8000 allow upgrading the firmware via the network interface. Details for acquiring the firmware and downloading the firmware to the camera are available on the Critical Link MityCAM Support Site.

12 Connecting via RNDIS to a Windows PC

1) Open the Network Connections dialog; it may be found by selecting Control Panel -> Network and Internet -> Network Connections.

2) Select and 'right-click' the "USB Ethernet/RNDIS Gadget #X" icon (underlined in red) and then select "Properties" from the pop-up menu.
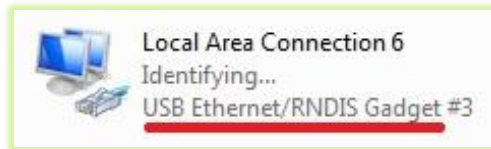

Figure 17: Typical Windows USB RNDIS Adapter Properties

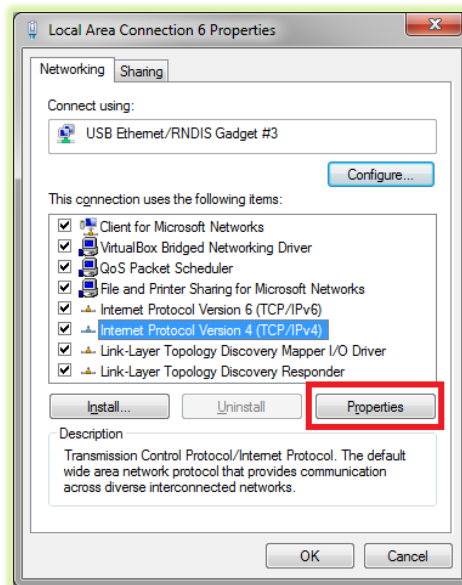3) Select "Internet Protocol Version 4" (TCP/IPv4) and then press the "Properties" button.

Figure 18: Internet Protocol Version 4 Properties Box

4) Enable static IP for the USB by NIC by setting the following parameters:
   a. Select "Use the following IP address"
   b. Enter IP address: 10.1.47.1
   c. Enter subnet mask 255.255.255.0
   d. Leave Default Gateway blank
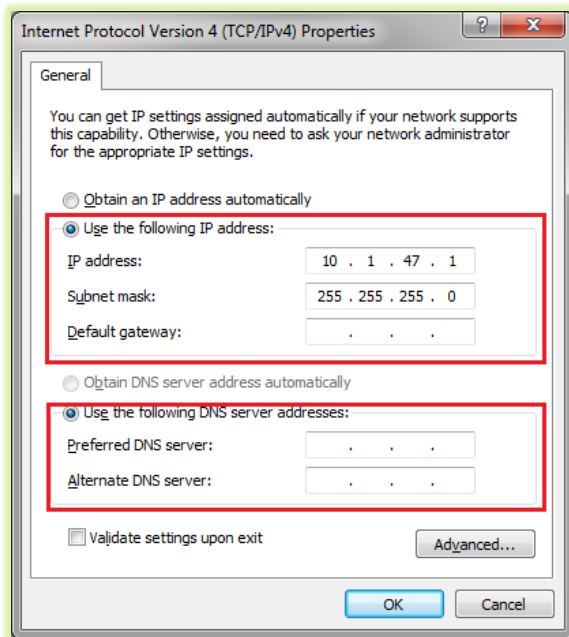   e. Select "Use the following DNS server addresses" radio button and leave blank

Figure 19: Static IP Configuration Settings

5) The USB RNDIS device is now configured for use with the MityCAM. Note that you can connect to the camera using SSH and SCP protocols. There is also a basic web interface for gathering serial number data and performing firmware upgrades.

13 Revision History

Revision	Date	Author	Description
A	05/12/2015	Jeff Myers	Initial Release
B	08/26/2016	Mike Williamson	Add information for AIA GigE Protocol. Add detail regarding external trigger timing. Add information on the FOT and sensor readout times.