

Interface Description for MityCAM-C8000 Camera Link Interface



(CT031 Revision 1)

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1 Purpose

This document describes the communications interface to Critical Link's Altera Cyclone V SOC based camera using CMOSIS Sensors, MityCAM-C8000. The MityCAM-C8000 with Dual Camera Link option provides an input power jack and a two standard Camera Link interface connectors. This document provides the details for both the power input and Camera Link interface.

1.1 Related Documents

Document #	Title	Description
60-000003	MityCAM-C8000 Datasheet	Complete specification for the MityCAM-C8000 product.
60-000008	MityCAM Camera Link Panel User's Guide	User's guide for generic MityCAM Camera Link panel application.
60-000009	MityCAM-C8000 User Manual	Details on basic and advanced Camera Link and MityViewer configuration and data acquisition. Also includes information regarding external triggering.

2 Camera Link Interface

Table below defines Camera Link signals:

Table 1 Camera Link Port 1 Connector

Cable Name	Camera Connector	Frame Grabber Connector	Channel Link Signal
Inner Shield	1	1	Inner Shield / GND
Inner shield	14	14	Inner shield / GND
PAIR1-	2	25	X0-
PAIR1+	15	12	X0+
PAIR2-	3	24	X1-
PAIR2+	16	11	X1+
PAIR3-	4	23	X2-
PAIR3+	17	10	X2+
PAIR4-	5	22	Xclk-
PAIR4+	18	9	Xclk+
PAIR5-	6	21	X3-
PAIR5+	19	9	X3+
PAIR6-	7	20	SerTC+
PAIR6+	20	7	SerTC-
PAIR7-	8	19	SerTFG-
PAIR7+	21	6	SerTFG+
PAIR8-	9	18	CC1-
PAIR8+	22	5	CC1+
PAIR9-	10	17	CC2+
PAIR9+	23	4	CC2-
PAIR10-	11	16	CC3-
PAIR10+	24	3	CC3+

Cable Name	Camera Connector	Frame Grabber Connector	Channel Link Signal
PAIR11-	12	15	CC4+
PAIR11+	25	2	CC4-
Inner Shield	13	13	Inner Shield / GND
Inner shield	26	26	Inner shield / GND

Table 2 Camera Link Port 2 Connector

Cable Name	Camera Connector	Frame Grabber Connector	Channel Link Signal
Inner Shield	1	1	Inner shield / GND
Inner shield	14	14	Inner shield / GND
PAIR1-	2	25	Y0-
PAIR1+	15	12	Y0+
PAIR2-	3	24	Y1-
PAIR2+	16	11	Y1+
PAIR3-	4	23	Y2-
PAIR3+	17	10	Y2+
PAIR4-	5	22	Yclk-
PAIR4+	18	9	Yclk+
PAIR5-	6	21	Y3-
PAIR5+	19	9	Y3+
PAIR6-	7	20	N/C
PAIR6+	20	7	N/C
PAIR7-	8	19	Z0-
PAIR7+	21	6	Z0+
PAIR8-	9	18	Z1-
PAIR8+	22	5	Z1+
PAIR9-	10	17	Z2-
PAIR9+	23	4	Z2+
PAIR10-	11	16	Zclk-
PAIR10+	24	3	Zclk+
PAIR11-	12	15	Z3-
PAIR11+	25	2	Z3+
Inner Shield	13	13	Inner Shield / GND
Inner shield	26	26	Inner shield / GND

3 Supported Camera Link Configurations

Several configurations of Camera Link are supported to allow for a larger range of evaluation options on different frame grabbers. By specifying an output mode and a BPP setting, the camera will be configured in the following manner:

Table 3 Available Camera Link Output Modes

Output Mode	BPP Setting	Camera Link Configuration	Full ROI Framerate
0 – Expanded	0 – 8 BPP	8 BPP, x10, 10-tap Camera Link	95 fps*
0 – Expanded	1 – 16 BPP	16 BPP, x5, 10-tap Camera Link	47.5 fps*
1 – Base	0 – 8 BPP	8 BPP, x2, Base Camera Link	20 fps**
1 – Base	1 – 16 BPP	16 BPP, x1, Base Camera Link	10 fps**

1 – Base	2 – 12 BPP	12 BPP, x2, Base Camera Link	20 fps**
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* When operating in expanded mode and continuously capturing, a proper master input clock must be provided. See the MityCAM-C8000 User's Manual (60-000009) for information about configuring the camera.

** When operating in Base mode, the frame rate should be set at or below this rate via the SFIT command.

Setting the frame-rate faster will cause problems outputting the data. If the ROI is reduced vertically (i.e.: fewer rows are set in the ROI), the frame interval can be decreased by an appropriate value. See the MityCAM-C8000 User's Manual (60-000009) for information about configuring the camera.

4 Communications

The command interface to the camera uses two sets of differential pair of signals for both communications to and from the camera. The underlying protocol is asynchronous serial communications:

- SerTFG: Differential pair from the camera to the frame grabber card.
- SerTC: Differential pair from the frame grabber card to the camera

A simple ASCII-based protocol is used to transmit and receive data between Critical Link's SOC Camera and frame grabber card. Commands are sent sequentially - one at a time - from a host PC through the serial data channel of a Camera Link interface. ASCII commands are processed by the onboard processor where each command is parsed and simple validation is performed. An ACK is returned if the command is validated and sent to the sensor, a NACK plus an error code is returned if the command was malformed, out of range or requested an invalid configuration.

The camera must not be capturing when a configuration change is requested; A NACK will be generated if a command cannot be executed while the camera is capturing.

4.1 Serial Settings

The configuration settings for the asynchronous serial port are fixed to 115200-8-N-1.

- 115200 baud
- 8 data bits
- No parity
- 1 stop bit

4.2 Available Commands

The following commands are available for use from an FPGA / frame grabber card on a host PC.

Table 4 Summary of Commands

Section	Command (Page)	Short Description
4.4.29	FAN (14)	Enable or disable the cooling fan
4.4.7	GBPP (9)	Gets the current bits-per-pixel output of the camera.
4.4.35	GCLK (15)	Get the current SCLK frequency to the sensor
4.4.16	GETP (11)	Get the state of all GPIO pins as a bitmask (0x00 through 0x07)
4.4.11	GEXP (10)	Gets the currently set exposure time of the frame.
4.4.13	GFIT (10)	Gets the currently set frame interval time of the camera.
4.4.31	GFLX (14)	Get Flip X state.
4.4.33	GFLY (14)	Get Flip Y state.
4.4.5	GHBN (9)	Gets the currently set horizontal binning factor.
4.4.8	GOMD (9)	Gets the Camera Link output mode of the camera.
4.4.21	GROI (12)	Gets the currently configured region of interest.
4.4.3	GVBN (8)	Gets the currently set vertical binning factor.
4.4.22	MROI (12)	Get/set a sub-region window.
4.4.23	NROI (13)	Enable/disable multiple ROI.
4.4.17	PEEK (11)	A request for the 32-bit data value at one of the sensor's readable registers.
4.4.18	POKE (11)	Sets the 32-bit data value in one of the sensor's writeable registers.
4.4.19	RSET (11)	Reset command, causes the processor on the board to halt execution and reboot
4.4.6	SBPP (9)	A request to set the bits-per-pixel output of the camera.
4.4.34	SCLK (15)	Set current SCLK frequency to the sensor
4.4.14	SETD (10)	Sets up the directions of the GPIO pins to input or output.
4.4.15	SETP (10)	Set one GPIO pin to high (1) or low (0) if it is set to an output using SETD
4.4.10	SEXP (9)	A request to set the exposure time of the frame.
4.4.12	SFIT (10)	A request to set the frame interval time for frames.
4.4.30	SFLX (14)	Enable or disable flipping the image to be output on the X axis.
4.4.32	SFLY (14)	Enable or disable flipping the image to be output on the Y axis.
4.4.4	SHBN (8)	A request to set the horizontal binning factor of the camera
4.4.9	SOMD (9)	A request to set the Camera Link output mode of the camera.
4.4.20	SROI (11)	A request to set the region of interest.
4.4.25	STOP (13)	Stops capturing if possible and applicable.
4.4.24	STRT (12)	Starts capturing data if a valid configuration is present.
4.4.2	SVBN (8)	A request to set the vertical binning factor of the camera.
4.4.28	TEMP (14)	Get the temperature of the sensor
4.4.26	TEST (13)	Turn on/off the test pattern and which test pattern is being used.
4.4.27	TRIG (13)	Set the trigger mode for the camera.
4.4.1	VERS (8)	A request for the hardware/software revision of the interface board

4.3 Error Codes

The camera will generate NACK response when it detects an invalid command or it's unable to execute the command. The response will consist of NACK followed by an error code. The camera will perform validation of configuration parameters when told to begin triggering or when a change in configuration occurs while capture is occurring. The current error codes are as follows:

Table 5 NACK Codes

Error Code Number	Description
1	Unrecognized Command
2	One or more arguments for the command was missing
3	One or more arguments for the command was out of range
4	Invalid configuration of camera
5	Capture in progress
6	Camera not responding
7	Operation not supported

4.4 Command Examples

4.4.1 VERS

A request for the hardware/software revision of the interface board

Request for version

Note: The format of the version command may change.

```
FORMAT --> <COMMAND>
COMMAND --> <VERS>
RESPONSE --> <ACK><1.0 1313>
```

4.4.2 SVBN

A request to set the vertical binning factor of the camera.

Set the vertical binning factor – Setting the vertical binning factor to 2.

Valid values for the vertical binning factor are 1 (no binning), 2, 4, or 8.

```
COMMAND-> <SVBN 2>
RESPONSE-> <ACK>
```

4.4.3 GVBN

Gets the currently set vertical binning factor.

Retrieve the currently set vertical binning factor.

```
COMMAND-> <GVBN>
RESPONSE-> <ACK><2>
```

4.4.4 SHBN

A request to set the horizontal binning factor of the camera

Set the horizontal binning factor – Setting the horizontal binning factor to 1.

Note: Horizontal binning is not currently supported.

```
COMMAND-> <SHBN 1>
RESPONSE-> <ACK>
```


4.4.5 GHBN

Gets the currently set horizontal binning factor.
 Retrieve the currently set horizontal binning factor.

```
COMMAND-> <GHBN>
RESPONSE-> <ACK><1>
```

4.4.6 SBPP

A request to set the bits-per-pixel output of the camera.
 Set the number of bits per pixel – Setting the mode to 8 BPP.

```
COMMAND-> <SBPP 0>
RESPONSE-> <ACK>
```

Table 6 Available Camera Link BPP Modes

Valid BPP Modes	Channel output mode
0	8 BPP
1	16 BPP
2	12 BPP

4.4.7 GBPP

Gets the current bits-per-pixel output of the camera.
 Retrieve the currently selected bits per pixel mode.

```
COMMAND-> <GBPP>
RESPONSE-> <ACK><0>
```

4.4.8 GOMD

Gets the Camera Link output mode of the camera.
 Get shutter mode – Get the shutter mode the camera is currently in according to the table in 5.4.14.

```
COMMAND-> <GOMD>
RESPONSE-> <ACK><0>
```

4.4.9 SOMD

A request to set the Camera Link output mode of the camera.
 Set output mode – Set the Camera Link output mode. The camera supports 2 Camera Link output mode configurations. This command is used in concert with the Set bits per pixel command to define that Camera Link configuration.

```
COMMAND-> <SOMD 0>
RESPONSE-> <ACK>
```

Table 7 Available Camera Link Output Modes

Valid Output Modes	Shutter mode
0	Expanded / 10-tap mode
1	Base mode

4.4.10 SEXP

A request to set the exposure time of the frame.
 Set exposure time – Requests to set an exposure time. The exposure time must be less than or equal to the rate of update. Exposure times greater than the update period will push the period of update to be equal to the

exposure time. If the exposure time cannot be matched, the camera will set the parameters to the closest possible valid exposure time.

Example: Set rate of exposure to 5ms.

```
COMMAND-> <SEXP 5000>
RESPONSE-> <ACK>
```

4.4.11 GEXP

Gets the currently set exposure time of the frame.

Get exposure time – Get the last set exposure time which was not out of range.

```
COMMAND-> <GEXP>
RESPONSE-> <ACK><5000>
```

4.4.12 SFIT

A request to set the frame interval time for frames.

Set frame interval time – Requests that a new frame be transmitted at the period specified. The resolution of the command is in microseconds. If the rate cannot be matched, the camera will set parameters to the closest possible valid rate of update.

If a rate is faster than the region of interest supports, the shortest frame interval time for the ROI will be used.

Example: Set interval time to 10ms (100 FPS).

```
COMMAND-> <SFIT 10000>
RESPONSE-> <ACK>
```

4.4.13 GFIT

Gets the currently set frame interval time of the camera.

Get the frame interval time – Get the last set frame interval time which was not out of range.

```
COMMAND-> <GFIT>
RESPONSE-> <ACK><10000>
```

4.4.14 SETD

Sets up the directions of the GPIO pins to input or output.

Set Pin Direction – Set the pin direction via index and value. Set pin 3 to be an output. 1 is for output, 0 is for input.

```
COMMAND-> <SETD 3 1>
RESPONSE-> <ACK>
```

4.4.15 SETP

Set one GPIO pin to high (1) or low (0) if it is set to an output using SETD

Set Pin – Setting pin 1 to low (0). Other valid values are high (1) and “expose strobe” (2).

NOTE: Exposure strobe is only available for pin CamIO 1.

```
COMMAND-> <SETP 1 0>
RESPONSE-> <ACK>
```

4.4.16 GETP

Get the state of all GPIO pins as a bitmask (0x00 through 0x07)

Get Pins – Response is a bit-mask corresponding to the value of pins 1 through 3

```
COMMAND-> <GETP>  
RESPONSE-> <ACK><8>
```

The above shows pin 3 is high, 0-2 are low.

4.4.17 PEEK

A request for the 32-bit data value at one of the sensor's readable registers.

Read register address 0x22:

```
COMMAND --> <PEEK 22>  
RESPONSE --> <ACK><1234>
```

4.4.18 POKE

Sets the 32-bit data value in one of the sensor's writeable registers.

Write hex value 0x1234 to register address 0x22:

```
COMMAND --> <POKE 22 1234>  
RESPONSE --> <ACK>
```

4.4.19 RSET

Reset command, causes the processor on the board to halt execution and reboot

Command to reset camera

Note: subsequent commands will no longer be accepted until reboot completes

```
COMMAND-> <RSET>  
RESPONSE-> <ACK>
```

4.4.20 SROI

A request to set the region of interest.

Set the region of interest as seen by the sensor. Specified are the start column, start row, width of region and height of the region. The origin (0, 0) will be specified as the upper left-most pixel in the entire field of view of the sensor.

Note: These values are with respect to the sensor; binning will reduce the number of pixels output by the camera.

CMV8000 ROIs require the following:

- Maximum number of rows less than or equal to 2496
- Maximum number of columns less than or equal to 3360
- Starting column must be a multiple of 16
- Total number of pixels must be a multiple of 64

If changing the ROI would produce an invalid exposure or frame interval (i.e.: interval time is too short for the larger ROI), the time will be adjusted to the closest value.

Setting a valid interval or exposure time for the new ROI before changing the ROI will not cause these values to change.

If multiple ROIs, are used, see MROI and NROI commands. See the MityCAM-C8000 User Guide for more information about multiple ROI.

FORMAT-> <SROI StartRow StartColumn Width Height>

Example: Setting full resolution

COMMAND-> <SROI 0 0 3360 2496>

RESPONSE-> <ACK>

4.4.21 GROI

Gets the currently configured region of interest.

Returns the current configuration for the region of interest.

COMMAND-> <GROI>

RESPONSE-> <ACK><StartRow><StartColumn><Width><Height>

4.4.22 MROI

Get/set a sub-region window.

Sets or gets a sub-region when in multi-ROI mode (when <NROI> returns a value greater than 1).

The format of the command is as follows:

<MROI index [start_col start_row width height]>

Get sub-region 0's dimensions:

COMMAND-> <MROI 0>

RESPONSE-> <ACK><0><0><3360><1000>

Set sub-region 1's dimensions:

COMMAND-> <MROI 1 0 1496 3360 1000>

RESPONSE-> <ACK>

4.4.23 NROI

Enable/disable multiple ROI.

Use this command to enter, exit and check the status of multi-ROI mode. To check the number of ROIs being used, issue the command with no parameters. The CMV8000 supports up to 8 separate ROIs.

When <NROI> returns 1, use SROI and GROI to set/get the region of interest. When <NROI> returns a value greater than 1, MROI must be used to get and set the sub-regions.

Check number of ROIs selected:

```
COMMAND-> <NROI>
RESPONSE-> <ACK><1>
```

Set number of ROIs to 3:

```
COMMAND-> <NROI 3>
RESPONSE-> <ACK>
```

4.4.24 STRT

Starts capturing data if a valid configuration is present.

Validates configuration of the camera and begins capturing frame data. This command may be expanded in the future to designate an external trigger to capture on.

```
COMMAND-> <STRT>
RESPONSE-> <ACK>
```

4.4.25 STOP

Stops capturing if possible and applicable.

If the camera is capturing, requests to stop capturing. Otherwise, this does nothing.

```
COMMAND-> <STOP>
RESPONSE-> <ACK>
```

4.4.26 TEST

Turn on/off the test pattern and which test pattern is being used.

Turn on or off the test pattern and which test pattern is being used.

```
COMMAND-> <TEST 0>
RESPONSE-> <ACK>
```

Table 8 Available Test Patterns

Value to write	Result
0	Test pattern turned off
1	Gradient from sensor
2	Digital pattern from FPGA

4.4.27 TRIG

Set the trigger mode for the camera.

Turn on external triggering/internal free-run.

```
COMMAND-> <TRIG 0>
RESPONSE-> <ACK>
```

Table 9 Available Trigger Modes

Value to write	Result
0	Internally triggered free-run
1	External trigger on CamIO 0

4.4.28 TEMP

Get the temperature of the sensor

Note: VPTAT conversion to temperature is not performed and only the voltage can be used.

COMMAND-> <TEMP 3>
RESPONSE-> <ACK><33.5>

Table 10 Available Temperature Sensors

Valid TEMP Arguments	Description
0	Reports voltage and converted temperature of all sensors.
1	Reports VPAT of the sensor.
4	Reports temperature Sensor on processor board.

4.4.29 FAN

Enable or disable the cooling fan

NOTE: Disabling the cooling fan may cause damage if the camera overheats.

COMMAND-> <FAN [1 | 0]>
RESPONSE-> <ACK>

4.4.30 SFLX

Enable or disable flipping the image to be output on the X axis.

Example: Disable Flip X functionality.

COMMAND-> <GFLX 0>
RESPONSE-> <ACK>

4.4.31 GFLX

Get Flip X state.

Example: Get flip x; it is enabled.

COMMAND-> <GFLX>
RESPONSE-> <ACK><1>

4.4.32 SFLY

Enable or disable flipping the image to be output on the Y axis.

Example: Disable Flip Y functionality.

COMMAND-> <GFLY 0>
RESPONSE-> <ACK>

4.4.33 GFLY

Get Flip Y state.

Example: Get flip y; it is enabled.

COMMAND-> <GFLY>
RESPONSE-> <ACK><1>

4.4.34 SCLK

Set current SCLK frequency to the sensor
The table below shows the supported values.

Table 11 Available SCLKs

Valid SCLK Arguments	IN_LCLK Value (MHz)		MCLK Value (MHz)
	10 bit	12 bit*	
0	n/a	126	21
1	125	150	25
2	137.5	165	27.5
3	150	180	30
4	180	216	36
5	200	240	40
6	250	300	50
7	275	n/a	55
8	300	n/a	60

Example: Set SCLK to 30MHz.

```
COMMAND-> <SCLK 30>
RESPONSE-> <ACK>
```

4.4.35 GCLK

Get the current SCLK frequency to the sensor
Get the currently configured SCLK.

Example: Get the current SCLK; it is 30MHz.

```
COMMAND-> <GCLK>
RESPONSE-> <ACK><30>
```

4.4.36 Invalid Commands

Issuing an invalid command will result in a NACK sequence as illustrated below.

Bad command (trying to set an input pin, assuming pin 2 was set to input):

```
COMMAND-> <SETP 2 1>
RESPONSE-> <NACK 3>
```

Bad command (missing required data value):

```
COMMAND-> <POKE 37>
RESPONSE-> <NACK 2>
```

Bad command (address out of range):

```
COMMAND-> <PEEK 8888>
RESPONSE-> <NACK 3>
```

Bad command (unrecognized due to misspelled command):

```
COMMAND-> <POEK 24 1234>
RESPONSE-> <NACK 1>
```

Bad command (ROI out of range):

COMMAND-> <SROI 0 0 2800 2160>
RESPONSE-> <NACK 3>

Bad command (Invalid configuration detected):

COMMAND-> <TRIG>
RESPONSE-> <NACK 4>

Bad command (Configuring while capture is in progress):

COMMAND-> <SROI 0 0 2560 2160>
RESPONSE-> <NACK 5>

5 Miscellaneous Details

5.1 Commands While Capturing

Commands which fetch information are safe to execute when not capturing images. Commands which set a parameter should only be executed when the camera is in a stopped state. This is to ensure that the sensor and all processing elements in the camera are properly configured before capturing data.

6 Revision History

Revision	Date	Author	Description
1A	5/2/2015	Mike Williamson / Jeff Myers	Initial Release.