Product Document

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High Resolution 70 Megapixel CMOS image sensor

CHR70M

Evaluation System Manual

Change record

| Issue	Date	Modification
1	28/11/2012	Origination
2	08/01/2014	Added Column Offset Calibration method
3	09/09/2014	Update for software version 1.3 Added subsampling details Removed "confidential" from footer

Table of Contents

1 SYSTEM DESCRIPTION

1.1 OVERVIEW

The purpose of this document is to give an overview of the test system which for the CHR70M 70Mp image sensor produced by CMOSIS. This test system can be used for testing and verifying the operation of the CHR70M image sensor.

1.2 BLOCK DIAGRAM
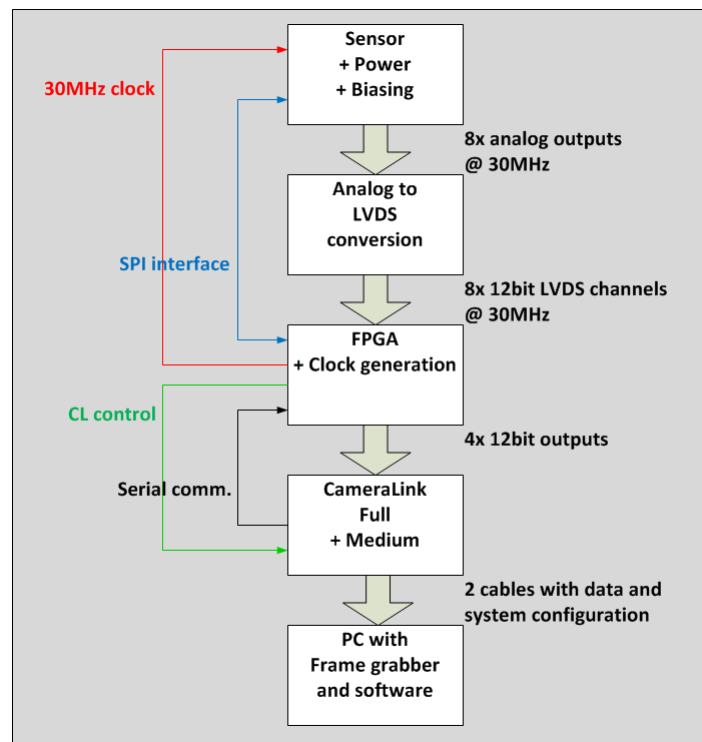
The block diagram above displays the different parts of the CHR70M test system. The three upper blocks are implemented on one PCB.

The fourth block is a standard third party frame grabber card which plugs into a PC's PCI Express bus (NI 1433). For this frame grabber and the PCB dedicated software has been developed in a LabVIEW environment.

1.3 CONTENTS OF THE TEST SYSTEM

The following components should be present when the CHR70M test system is delivered.

- CHR70M board with lens holder
- Metal casing
- Power cable
- Nikon Lens Nikkor AF 50mm f/1.8D
- 2 CameraLink cables (2m)
- NI PCI1433 frame grabber card (inside PC)
- Lenovo ThinkCentre mini tower model + software
- CD with documentation and software

1.4 CHR70M BOARD

1.4.1 LENS HOLDER
The CHR70M PCB is equipped with a F-mount lens holder and lens.

1.4.2 SENSOR + POWER AND BIASING
This part of the test board includes the sensor, its power sources and biasing (decoupling to ground). Below you can see the demo system. On the left is the power connector which has to go to a 5V/+12V/-12V power supply with 500mA per supply. On the right you have the base and medium CameraLink cables to the frame grabber.

1.5 FPGA

The FPGA has 6 important roles in the test system:

1. Accept the LVDS data from analog to LVDS converter.
2. Generate the necessary driving signals for the sensor
3. Generate the clocks needed by the sensor and CameraLink interface
4. Communicate with the sensor over the SPI interface
5. Communicate with the PC over the serial interface of the CameraLink
6. Prepare the data for the CameraLink interface
7. Send the data to the CameraLink interface together with the control bits and clocks

Taking the requirements above into account, we have chosen Xilinx Spartan 6 FPGA for our test system. All functionality described in the requirements above is programmed into the FPGA. Communication between the PC and FPGA is possible using the serial channel of the CameraLink interface.

1.6 CAMERALINK INTERFACE

The interface between the test board (camera) and the PC uses the CameraLink standard. This standard is supported by many frame grabber cards on which the raw image data will be dumped. The test board is able to grab images at the 360Mbps (30MHz analog output converted to 12 bit LVDS per channel).

2   FRAME GRABBER AND PC

A frame grabber card which can accept the Medium and Full CameraLink interface was chosen to complete the test system interface. The NI PCIe-1433 allows raw image data to be dumped at 4.8Gbit/s on the PC. This card is fitted in a PCI Express slot of the test system PC and uses two dedicated cables to connect to the CHR70M board.

The PCIe- 1433 frame grabber card comes with an API, which can easily be used in LabVIEW. This API is used to communicate with the frame grabber card and read the image from memory to display it on the screen.

See http://www.ni.com/pdf/manuals/372015a.pdf for more details on the PCIe 1433 frame grabber card.

The PC in which the frame grabber card is inserted and on which the software is running has the following minimum requirements:

- Intel Core i3
- 2 Gbyte DDR memory
- 500GB SATA hard disk
- Intel HD Graphics
- 16x DVD-ROM
- PCI-Express slots

On this PC, the LabVIEW RunTime Engine and the Vision Development Module will be installed. A dedicated CHR70M.vi program is written to grab and save images from the camera board. A detailed description of the software can be found in the next section.

3 INSTALLING THE SYSTEM

When installing the system, the following connections have to be made:

1. Connect the PC to its peripherals (keyboard, mouse and monitor) and power up.
2. Connect the demo board to a power supply (+5V/+12V/-12V). Their individual grounds are connected on the board.
3. Connect the board to the PC via the two camera link cables. Use either cable to connect the camera link connector on the PCB labeled 'base' to the PC camera link port labeled 'base'. Use the other cable (medium) to connect PCB port 'medium' to the other frame grabber port on the PC

4   RUNNING THE SYSTEM

4.1   SOFTWARE OVERVIEW

Next figure shows a screenshot of the demo software.
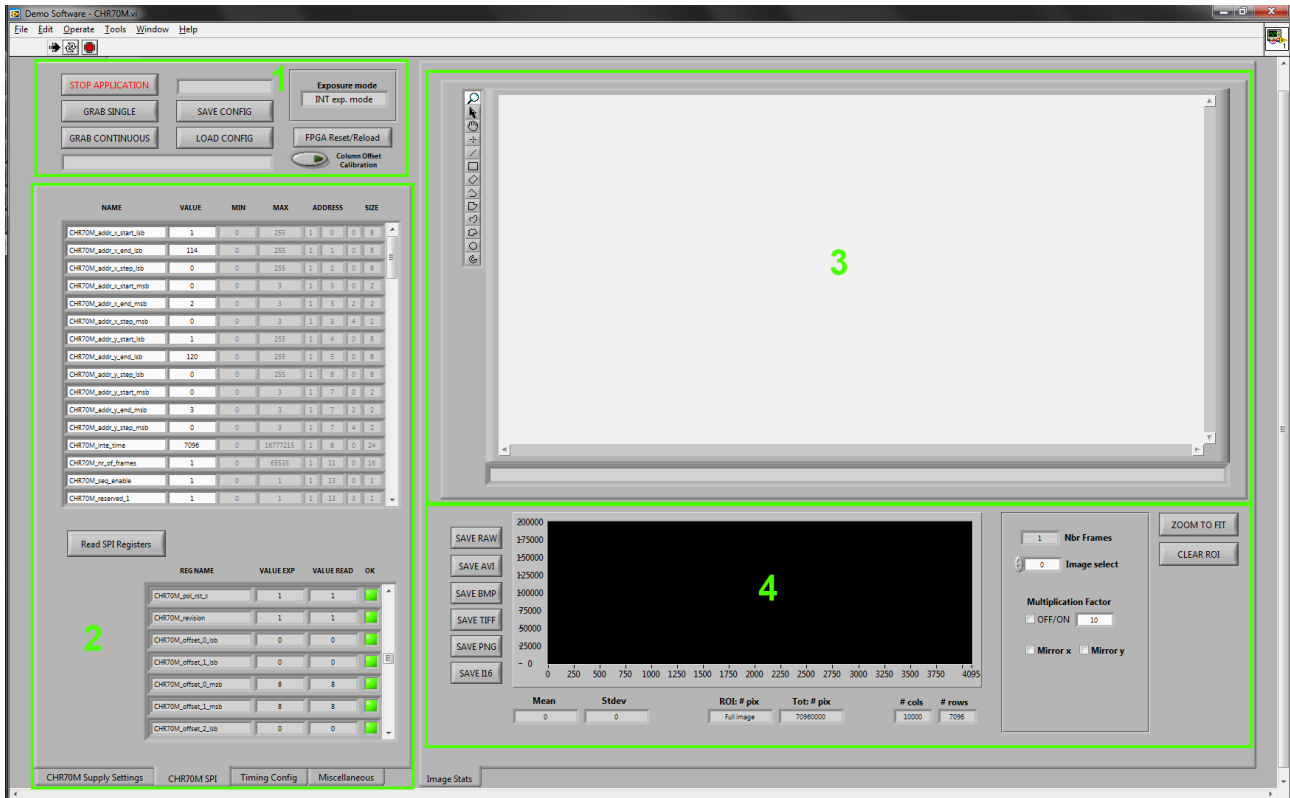
The four main areas of the software are:

1. **Control area:** The user can control the software (grab frames, save and load configuration files …) via a number of push buttons.
2. **Register settings area:** The user can set the registers of the sensor. The registers are grouped into a number of tabs for better readability.
3. **Image area:** The images acquired from the sensor are displayed in this image viewing plane.
4. **Image statistics area:** A number of image and software statistics are displayed here.

Next section will explain the different software functions in more detail.

4.2 SOFTWARE DETAILS

4.2.1 CONTROL AREA
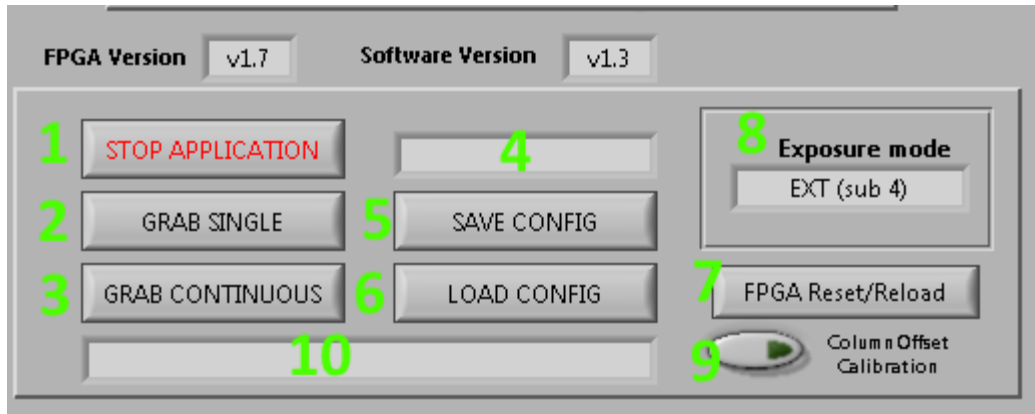
The 10 controls in the Control Area are:

1. **STOP APPLICATION** button: Click this button to stop the application from running and exit to the labview run-time environment. Then the window can be closed. It is required to use this button to stop the program, instead of closing the window while it is still running.
2. **GRAB SINGLE** button: Click this button to grab a single sequence of frames. The number of frames in the sequence is set in the 'register settings area'. When the single grab has finished, the 'image 'area' will be updated. Because of framegrabber and physical PC memory, the number of frames which can be grabbed sequentially is limited to 3.
3. **GRAB CONTINUOUS** button: This button has the same function as the 'grab single' button. The difference is that this button has a different latching action. By clicking it once, it will be enabled. As long as it is enabled, the software will continuously request sequences of frames and update the image area. This mode is also called 'video mode'. To stop the video mode, click the 'grab continuous button' again. This will reset the button to its disabled state.
4. **INFO TEXT BOX**: This will contain info about the state of the sensor or software errors. If an error occurs during image grabbing, it is reported in this message window. If an error message occurs, check if the camera link cables are plugged correctly and if the sensor is plugged correctly. These are the most common sources of frame grabbing errors.
5. **SAVE CONFIG** button: By clicking this button, a configuration file can be saved. A configuration file is a human-readable version of the sensor register map. The advantage of a configuration file is that it can be reloaded into the software using the 'load config button'. (Tip: save the configuration files with a .txt extension).
6. **LOAD CONFIG** button: By clicking this button, a configuration file can be loaded into the software. When this is done, all settings from the 'register settings area' are overwritten with the information from the configuration file. The new settings are automatically transferred to FPGA and sensor (no need to click the 'reload FPGA button' after loading a configuration file).
7. **FPGA Reset/Reload** button: The FPGA is reset and the settings from the 'register settings area' are uploaded to the FPGA and sensor. This means that a value is transferred only when it is changed by the user in the software. This button should be clocked after loading a configuration file.
8. **Exposure mode** label: This shows if the sensor is running in internal sequencer mode or with external timings in external mode.
9. **Column offset calibration** button: Because the channels of the sensor and the ADC's on the PCB can have a slightly different offset compared to each other, this button is used to automatically change the offset per channel so they have all the same visual offset. Click this button to enable it and then click the GRAB

CONTINOUS button to start the calibration loop. After it is done, you click this button again to stop the calibration. See further for more details.

10. **INFO TEXT BOX**: Containing info about the configuration file

Note: On the Desktop of the evaluation PC, there are two configuration files; one for internal and one for external mode. You can load this configuration file into the software with the 'load config button'. This configuration file contains the advised values for optimal sensor operation.

4.2.2   REGISTER SETTINGS AREA
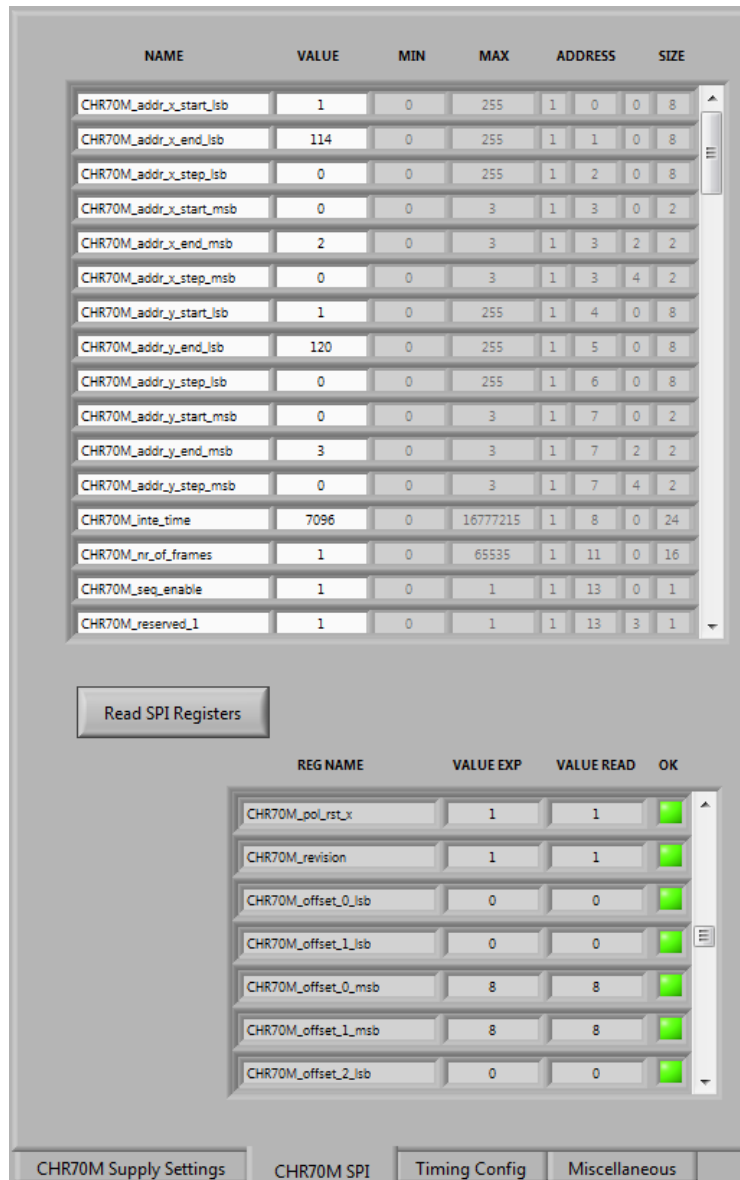
The 'register settings area' can be used to change all sensor registers. All registers in the sensor can be changed or readout from here. Most of these settings can be left unchanged by the user of the evaluation system. It is advised to only use the CHR70M SPI tab, as the other tabs refer to the FPGA and ADC's on the PCB and their settings are adjusted so the system works properly.

Every register setting in this list refers to a sensor register (see data sheet for complete register map). The user of the evaluation system can only change the 'value' of the registers. The other entries are informational. (Tip: the register addresses (third column from the right) match the address values in the register map in the datasheet).

Upon hitting the enter key after changing a value of a register, it is uploaded to the FPGA. Note that it is allowed to change register settings while in video mode. The changes will reflect immediately in the displayed images.

4.2.3 IMAGE AREA

The images that are acquired from the sensor are displayed in the 'image area'. Only one image is displayed. If a sequence of frames is acquired, the entire burst is in the memory. A selection switch in the 'image statistics area' can be used to select which frame from the sequence is displayed.

Next to the image plane is a small toolbar with image controls. These can be used to zoom in the image and to select region of interest (ROI) contours for the image statistics. Next figure shows this toolbar.


Of these tools, the following 5 are most commonly used:

1. **ZOOM**: When selected, the mouse pointer turns into a magnifying glass when moved over the image. Every click will zoom into the image by 1X. When holding the SHIFT key on the keyboard, the mouse pointer will turn into a magnifying glass with a small 'minus sign' in it. Clicking in the image with the SHIFT key held will zoom the image out by 1X.
2. **PAN**: When the image is zoomed, this function allows the user to pan the image.
3. **POINT ROI**: Allows the user to set an ROI in the image of exactly 1 pixel. Click on the image to place the point ROI.
4. **LINE ROI**: Allows the user to set a line ROI in the image. Click on the image to set the first point of the line. Hold the left mouse key and drag to where the end point of the line should be. Release the left mouse button to place the line.
5. **RECTANGLE ROI**: Allows the user to set a rectangular ROI in the image. Click on the image to set the first corner of the rectangle. Hold the left mouse key and drag to the point where the opposite corner of the rectangle should come. Release the left mouse button to place the rectangle.

More information on the ROI statistics can be found in the 'image statistics area' section.

4.2.4   IMAGE STATISTICS AREA

Next figure shows the image statistics area.
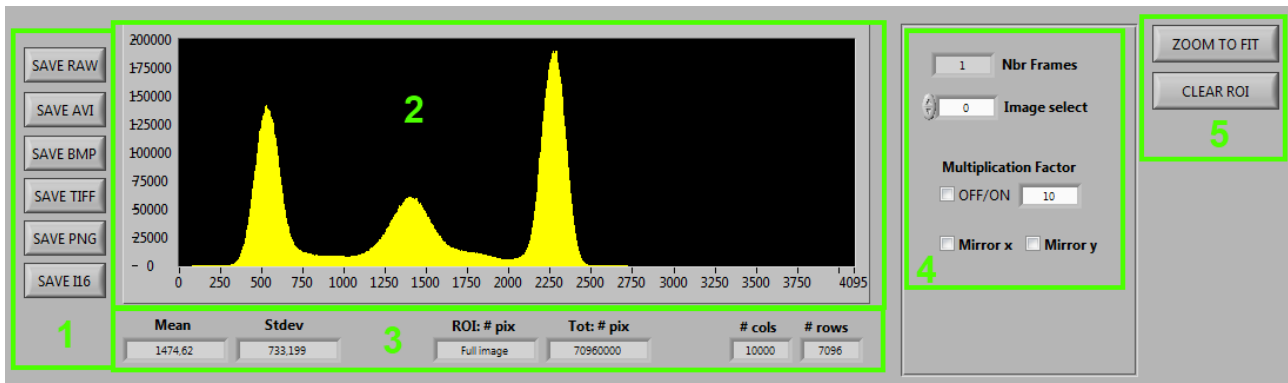
The 'image statistics area' consists of:

1. **SAVE BUTTONS**: Clicking these buttons will save the requested image(s) in a specific file format. Set the path and name and the software will automatically add the frame number per image.
2. **HISTOGRAM:** Contains the histogram of the full image or ROI if selected.
3. **Image information:** This section contains information about the current image and ROI.
4. In this section you can view how many frames are requested per frame request. You can scroll through the frames taken. You can add a digital multiplaction (gain) to the image (this will only reflect the image on screen and not the saved images). And you can set software mirroring (this will only affect the image on the screen and not the saved images)
5. **ZOOM TO FIT and CLEAR ROI** buttons: these will zoom out to fit the image and clear the selected ROI.

4.3   STARTING THE SOFTWARE

Log on to the PC using the 'demo user' account. No password is needed.

Power on the power supplies before starting the software. The current off each supply should be around 315mA.

On the Desktop, there is a link to the demo software executable, called "Demo Software – CHR70M.exe". Double clicking this shortcut will launch the demo software.

After the software is launched, load a configuration file and click the FPGA Reset/Reload button. Now the FPGA will be reset, the sensor is configured, the ADC training will be done and a single frame will be taken. If an image shows up on the screen then this initialization was successful.

4.3.1   ERRORS

If for some reason the initialization is not successful or another error shows up, you can see if the ADC training was successful in the Miscellaneous tab. This tab also contains info about the previous error which occurred. If everything fails, close the software, reboot the power supplies and restart the software.

Also check if the supplies give the right amount of current/power. This should be around 300mA for each supply.
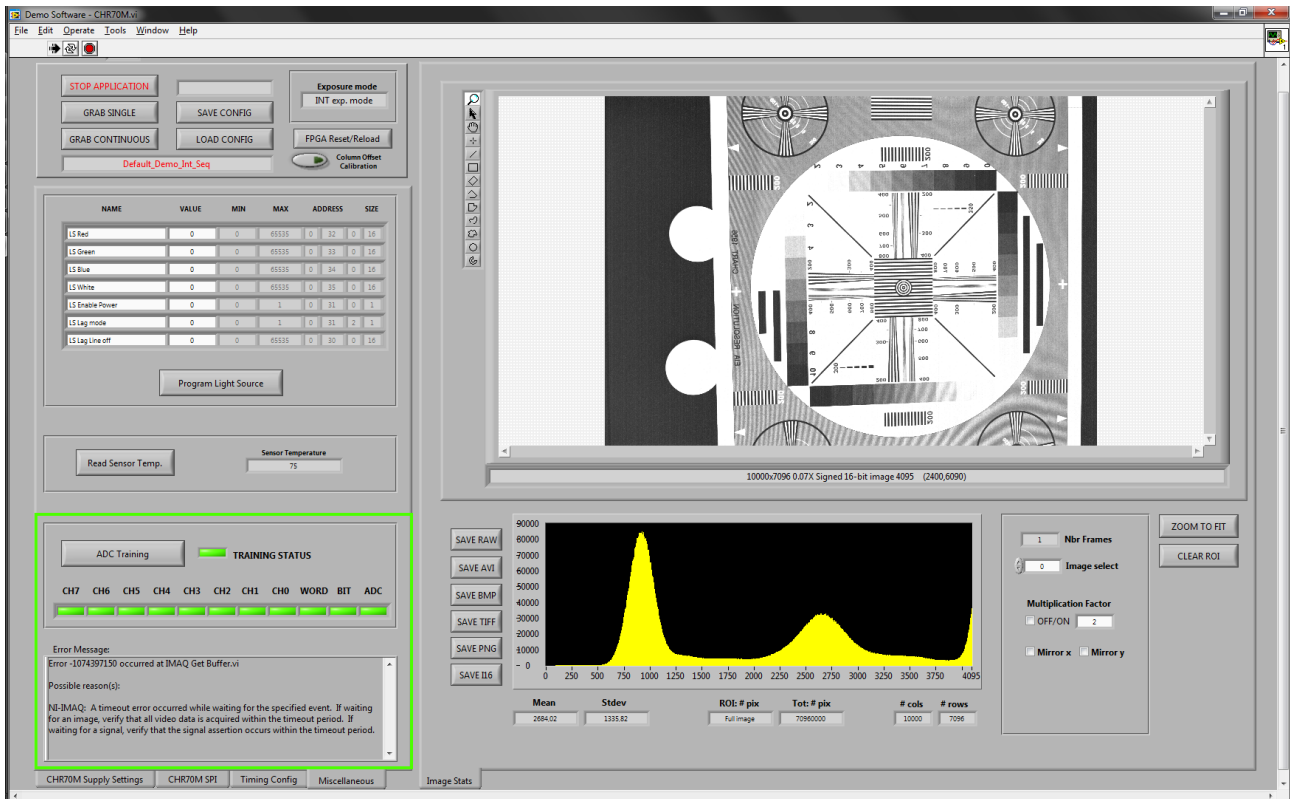
4.4 COLUMN OFFSET CALIBRATION

Because the offsets of the different channels can be different (and also the offsets of the PCB ADC's) it is recommended to change the offset registers of every channel until an even image is received. Manually adjusting these registers can be difficult, that is why the software provides an automatic calibration for this.

Follow the next sequence after you have loaded a certain (disable the multiplication factor when doing this):

1. Cover the lens/sensor so absolutely no light is coming through.
2. Set the exposure time low (1-5 line times). You will have an image that looks like the one below with column non-uniformities in it and a bad histogram.
3. Click the GRAB CONTINUOUS button
4. Click the Column Offset Calibration button (it will light up)
5. You will now see that the offset registers are automatically adjusted with every frame and the image and histogram becoming more and more even.
6. Wait until the image doesn't improve anymore (look at the standard deviation). This will take about 10 frames.
7. Click the Column Offset Calibration button again to stop the calibration (light will go out)
8. Click the GRAB CONTINUOUS button to stop grabbing. It is important to do this only after you have disabled the calibration.
9. If you want to change the overall offset, just change the offset of one channel and look at the histogram until you've set it to your liking. Now just change the offset registers of every other channel with the same amount as that channel. See figures 3 & 4.
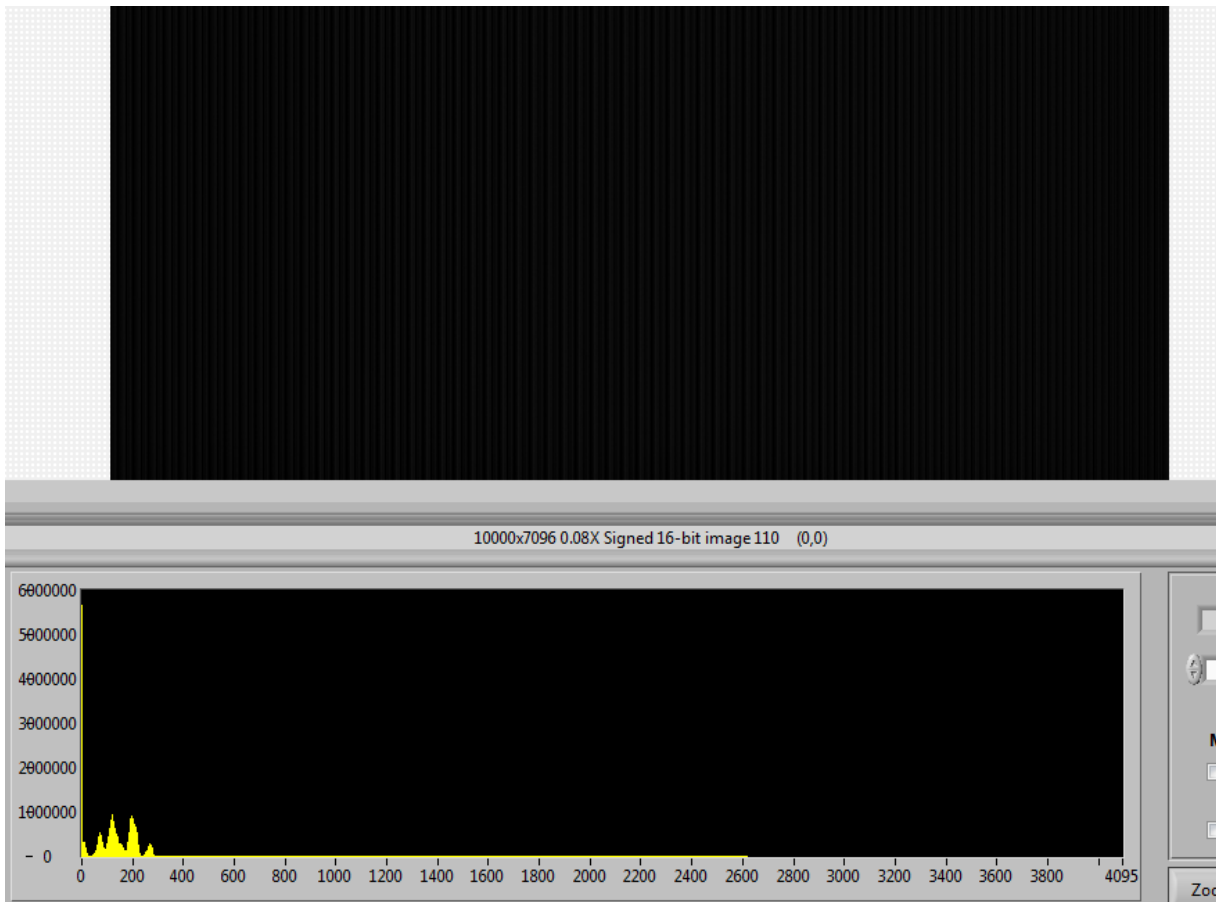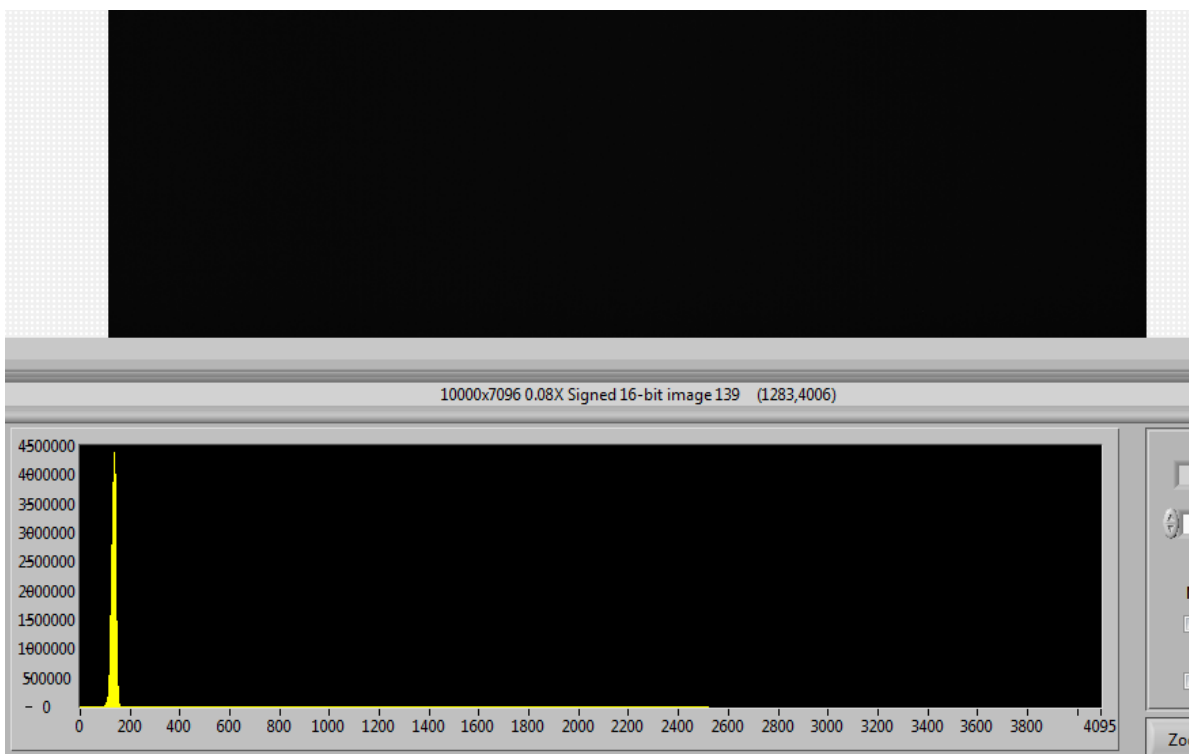
10000x7096 0.08X Signed 16-bit image 110   (0,0)

FIGURE 1: BEFORE CALIBRATION

10000x7096 0.08X Signed 16-bit image 139   (1283,4006)

FIGURE 2: AFTER CALIBRATION

10000x7096 0.08X Signed 16-bit image 71 (0,0)
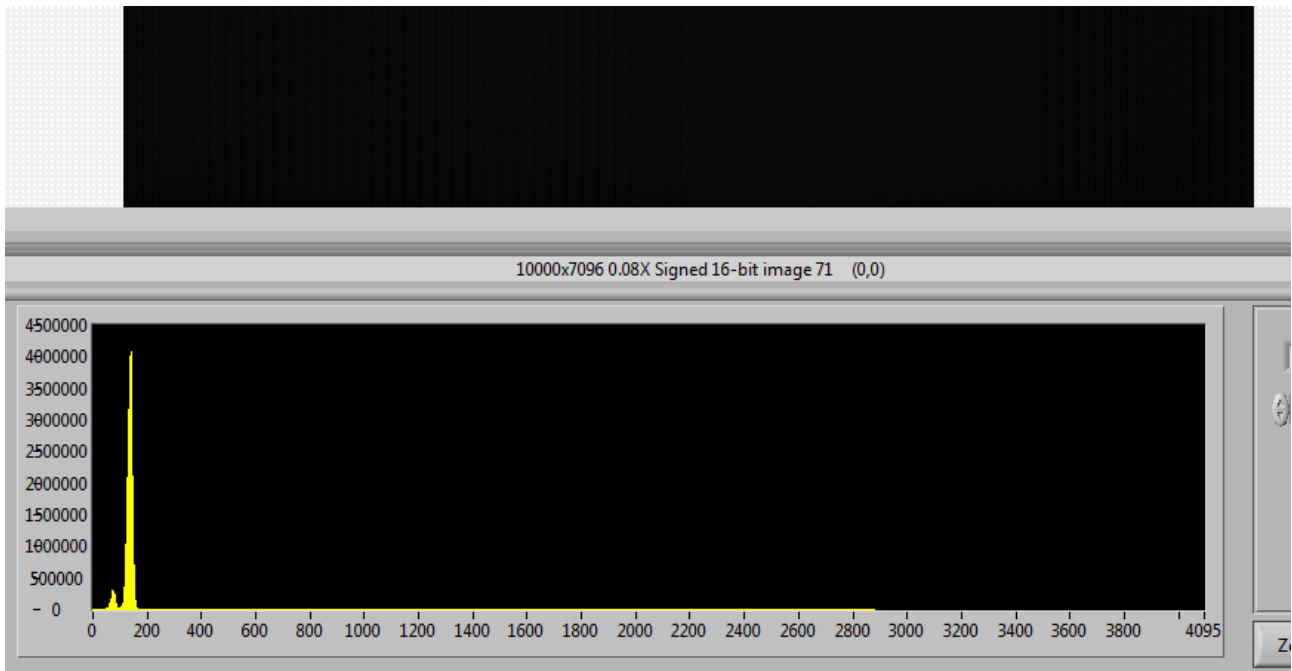
FIGURE 3: LOWERED THE OFFSET OF 1 CHANNEL

10000x7096 0.08X Signed 16-bit image 68 (0,0)

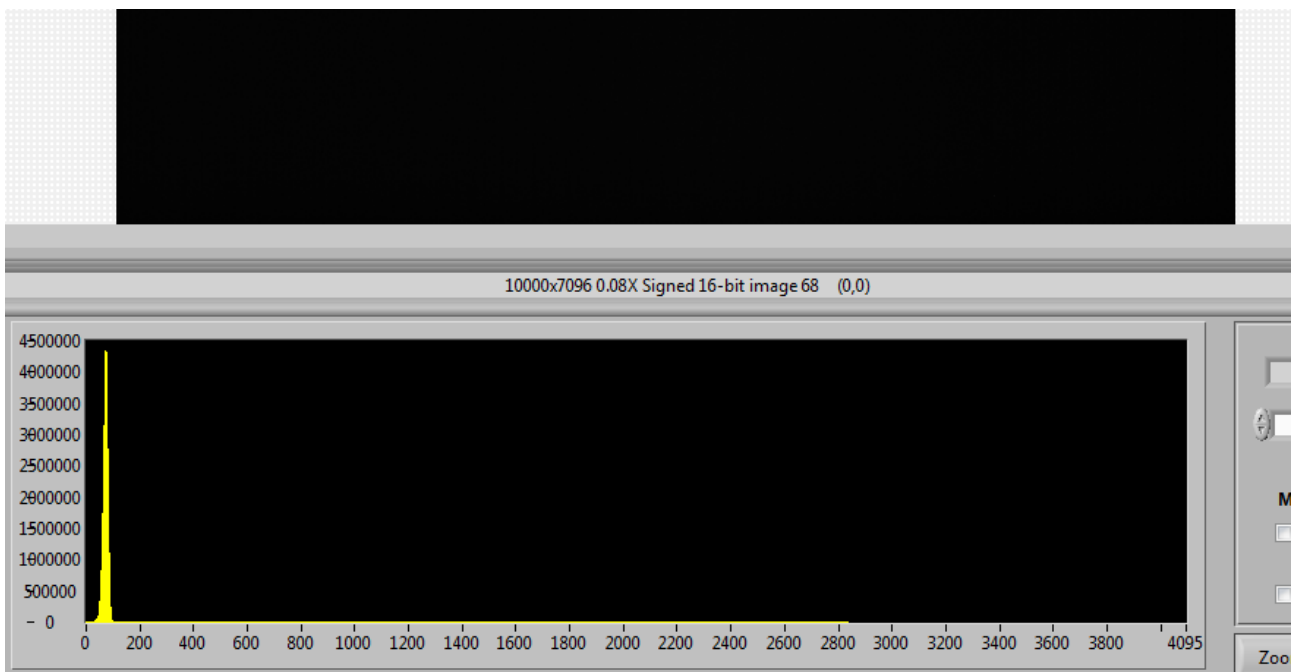**FIGURE 4: LOWERED ALL OTHER CHANNELS**

4.5 SUBSAMPLING

When you want to enable subsampling with the internal sequencer, set the sensor register CHR70M_sub_y to 1. Then on the Timing Config tab, set the Subsampling register to 8. This is the only subsampling mode the sensor supports when using the internal sequencer. When using another subsampling number, the Exposure Mode text box will show INVALID and no frames can be taken.

When disabling the internal sequencer the software will use a fixed external timing to control the sensor. Now you can use the Subsampling register on the Timing Config tab to choose 0-2-4-16-32-64-128 subsampling (where '0' is no subsampling).