# Technical Note

## MT9T013
## Lens Shading Correction (LC)

## Introduction

This technical note explains the lens shading correction method and calibration procedure to automatically obtain lens corrected images with Micron's MT9T013 CMOS image sensor. Camera modules have signal degradation on sensor periphery due to optical and geometrical factors. Lens shading correction compensates the signal degradation by digitally gaining pixels on the image periphery. In the MT9T013, the lens shading correction function is performed on all four color channels—red, greenR, blue, and greenB.

## Lens Shading Correction (LC) Method

LC is performed on Raw10 Bayer data in the datapath. In the context of the signal chain, lens shading correction is located after digital gain, before pixel data is output from the sensor, as shown in Figure 1.

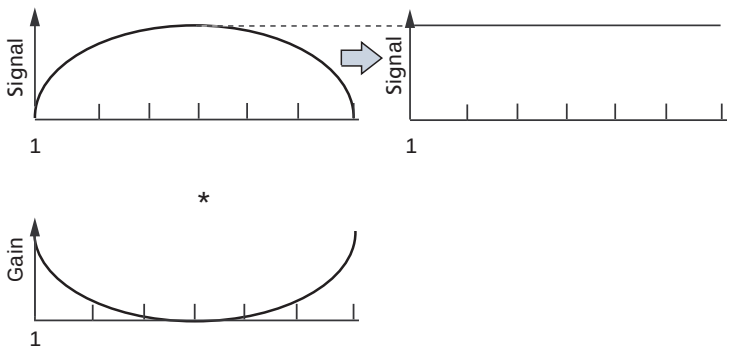
LC can be enabled or disabled by programming data bit field R0x3780 bit[15] to "1."

**Figure 1: Lens Shading Correction In Signal Path**


LC is implemented by multiplying the value of incoming pixel data $S_i(x,y,c)$ by the value of the correction function G(x,y,c), which is calculated based upon the position and the color channel of the array sensor. The resulting output pixel data $S_o(x,y,c)$, is given in the following formula:

$$S_o(x,y,c) = S_i(x,y,c) * G(x,y,c) \quad \text{(EQ 1)}$$

**Figure 2: Before and After Signal**



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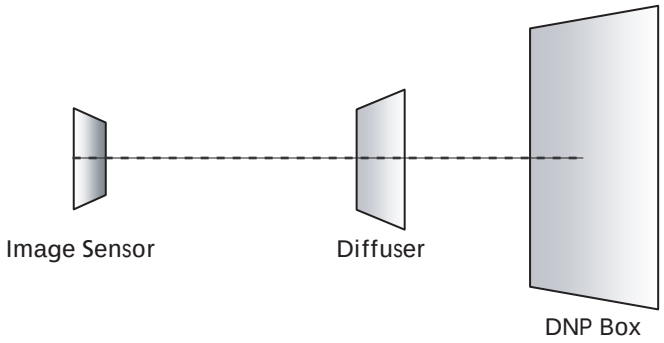
# Lens Calibration Procedure

## Setup

1. Start up DevWare and camera in the default state (load default register settings).
2. Point the camera at a flat and uniformly illuminated calibration target (the variation in light intensity should be no more than 2 percent over the entire FOV at a color temperature of approximately 5000K). The light source and sensor demo system should be shielded from external light sources.

**Figure 3: Lens Correction Setup**




## Switch to Full Resolution

By default, the sensor is in full resolution mode (2048 x 1536). If the sensor is not in full resolution, return to full resolution. Use the "Zoom Out" button from the toolbar to fit the entire image within the current view.



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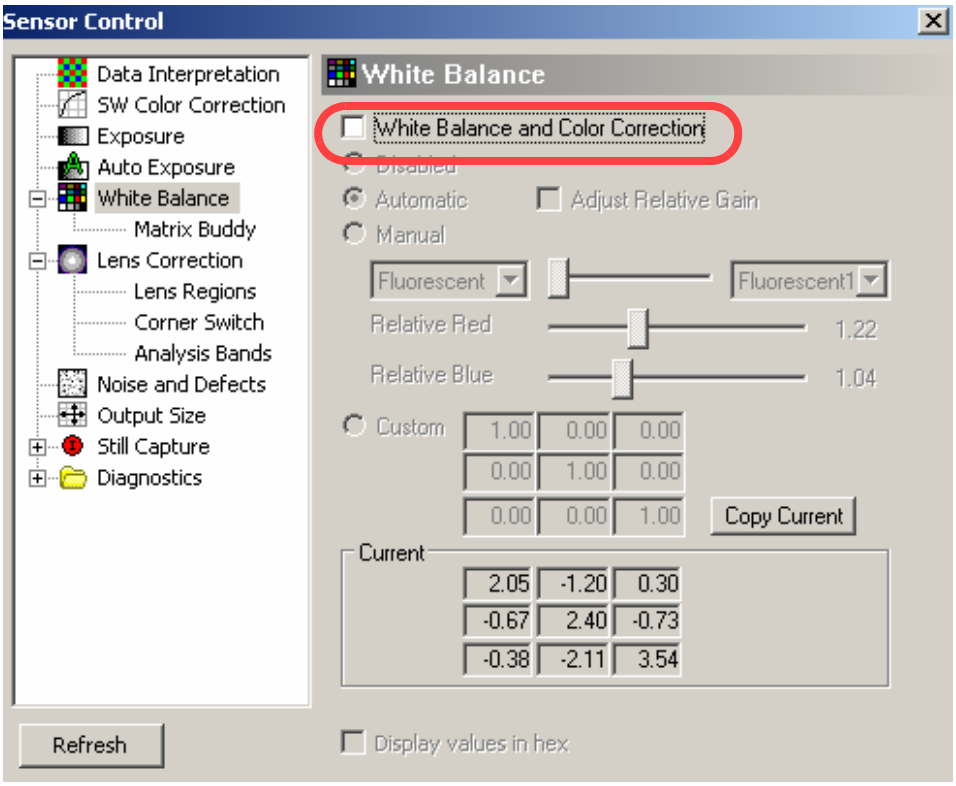
## Turn Off Color Processing

From the toolbar, select "Preset," then select and load "Color Processing Off." This should disable (uncheck) the following functions:

- SW Color Correction (including Gamma and Contrast)
- Exposure
- Auto Exposure and Auto White Balance
- Color Correction

For example, Figure 4 shows the Auto White Balance and Color Correction box is unchecked (disabled) in the Sensor Control Window.

**Figure 4: White Balance**



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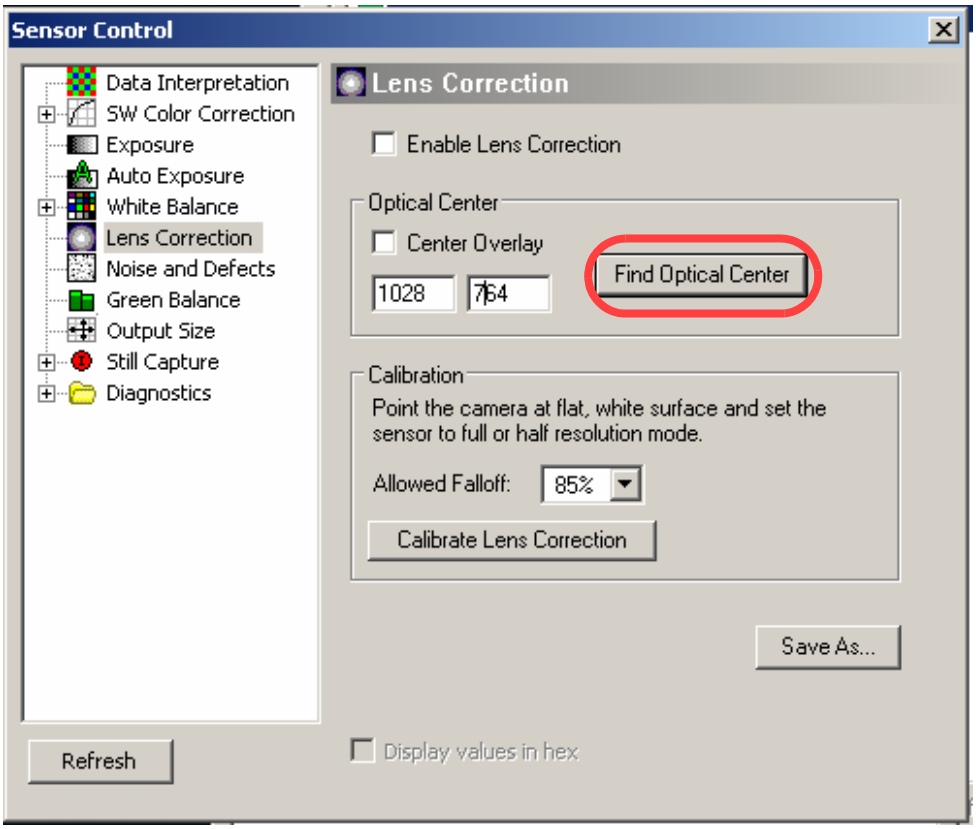
## Calibration

1. Find the center of the lens by going to Sensor Control –> Lens Correction.

Click on "Find Optical Center" and watch the zones readjust on the image.

**Figure 5: Lens Regions**




2. Set the row and column line at the middle row/column of the image. In full resolution mode, the row line is set at 768 with column line at 1024. The mouse cursor position can be read from the "Info" panel on the left side of the screen.



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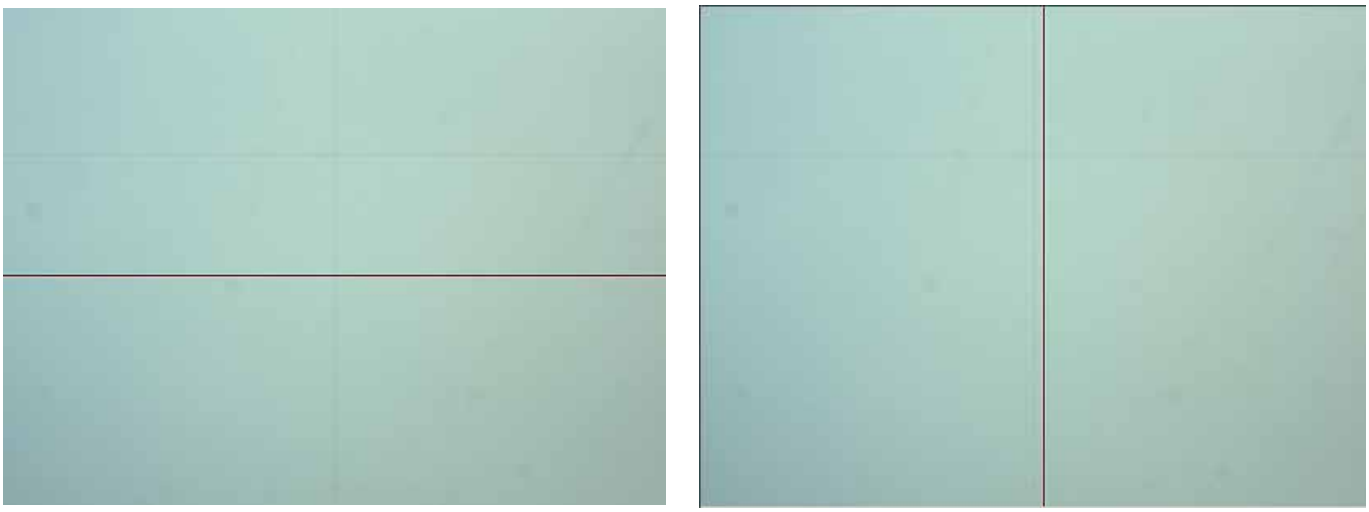
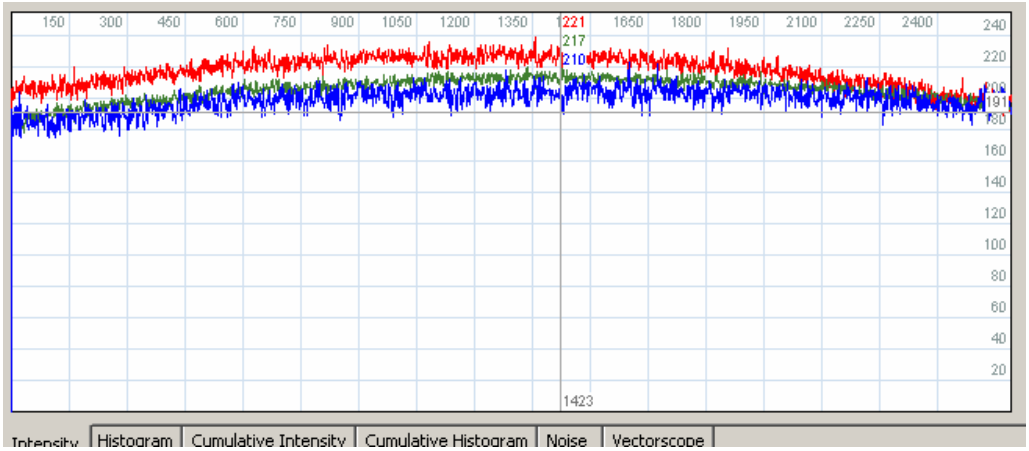
**Figure 6: Sensor Array Row and Column Selection**



3. Open Analysis Graph and view the Intensity plot of the middle row/column of the image—the graph should be similar to Figure 7. Right-click on the Analysis Graph window and select “Plot Bayer Data.” This will show both the greenR and greenB channels.

**Figure 7: Intensity Graph**



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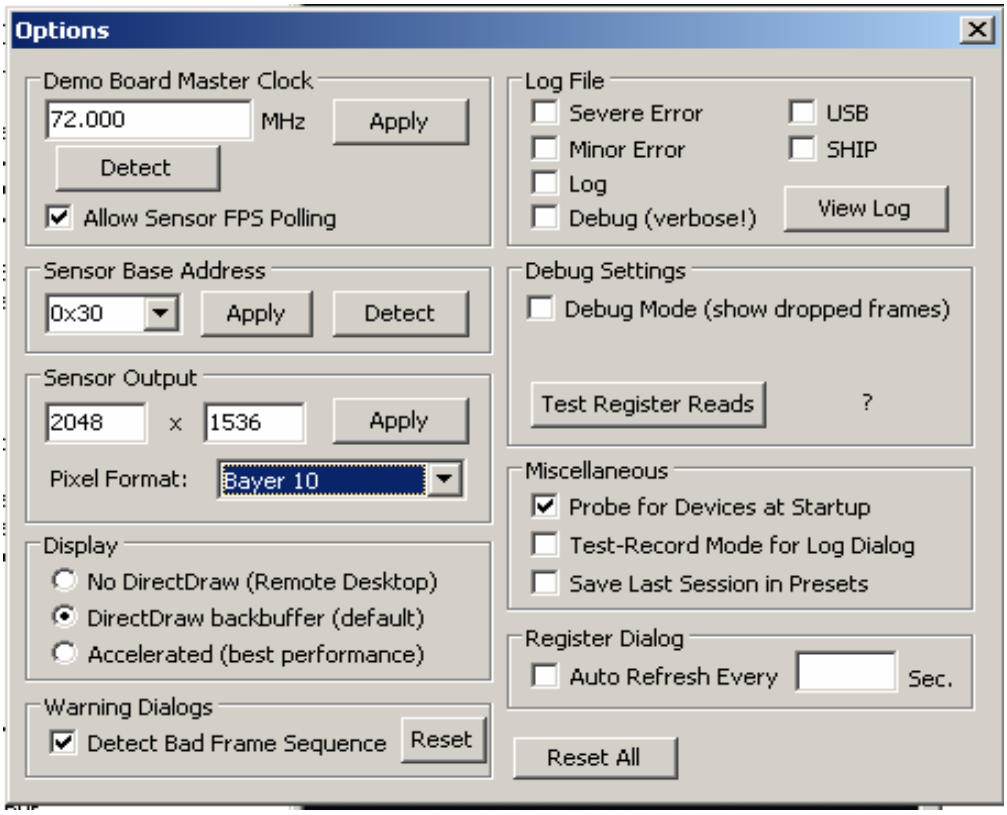
4. Open the “Options” window under the View tab. Under “Pixel Format,” set the pixel format to “Bayer 10.”

**Figure 8: Change Sensor to 10-bit**




5. Adjust peak intensity to approximately 200. From the Register window (click on the "Register" icon in the toolbar), adjust the coarse_integration_time register (R0x3012) such that the peak intensity of the green curves is not or around 180–200. The red and blue curve should not clip in this condition; the intensity value should not exceed 255. If clipping occurs, try using a different uniform light source or manually lowering the analog gains—R0x3056 for greenR, R0x3058 for blue, R0x305A for red, and R0x305C for greenB.



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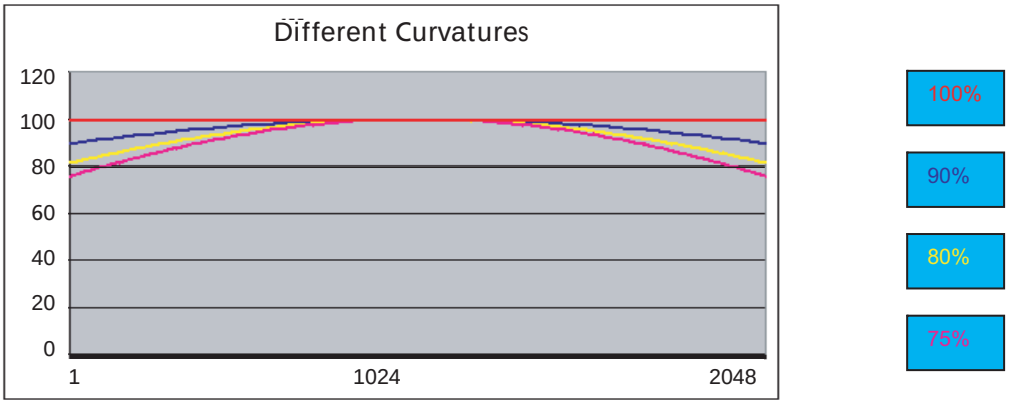
6. Return to the “Lens Correction” window. Choose the allowed “Percentage Fallout” for the LSC. Click on “Calibrate Lens Correction.” DevWare will calculate the LC based on the flat field image it is viewing. Then choose “Enable Lens Correction” to view the corrected flat field image.

**Figure 9: Curve Percentage**




7. Use the “Save As” button to save the new register settings.



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## Results

Figures 10 through 16 show a set of data images before and after the lens correction calibration procedure. The intensity graphs are plotted in horizontal, vertical, and diagonal profiles.

**Figure 10: Before LC Image**

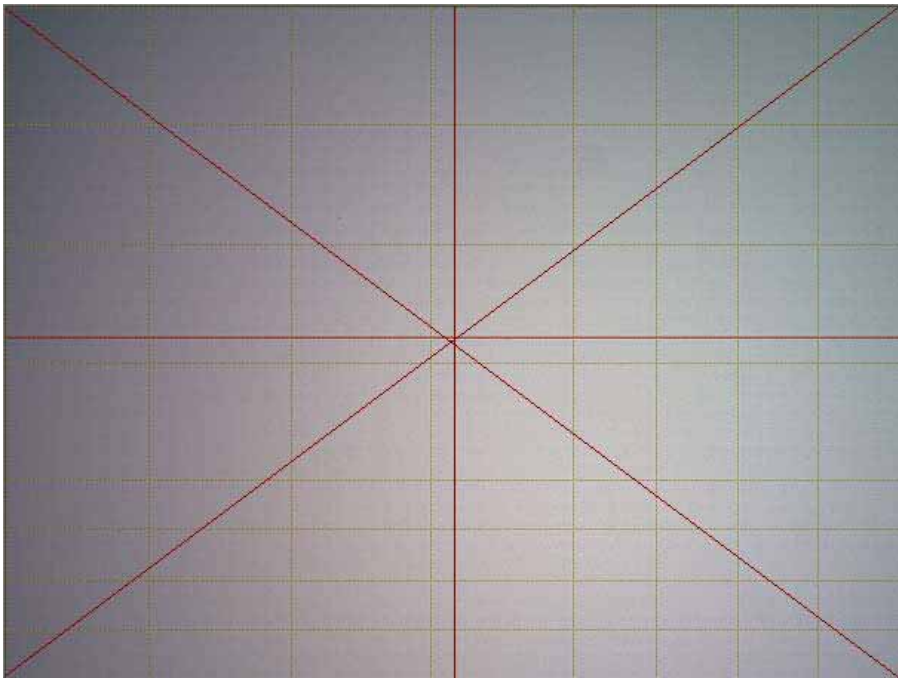
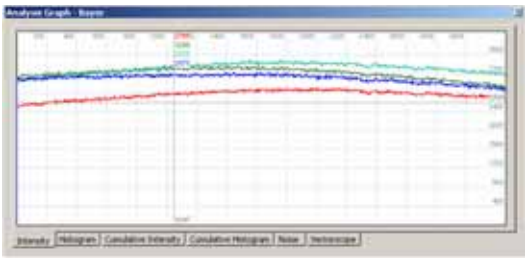
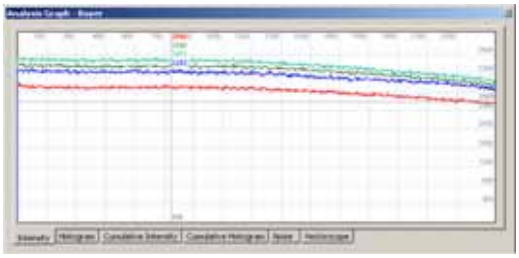


**Figure 11: Before LC Intensity Graphs**



Before LC Intensity Graph (horizontal)



Before LC Intensity Graph (vertical)



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**Figure 12: After LC Image**

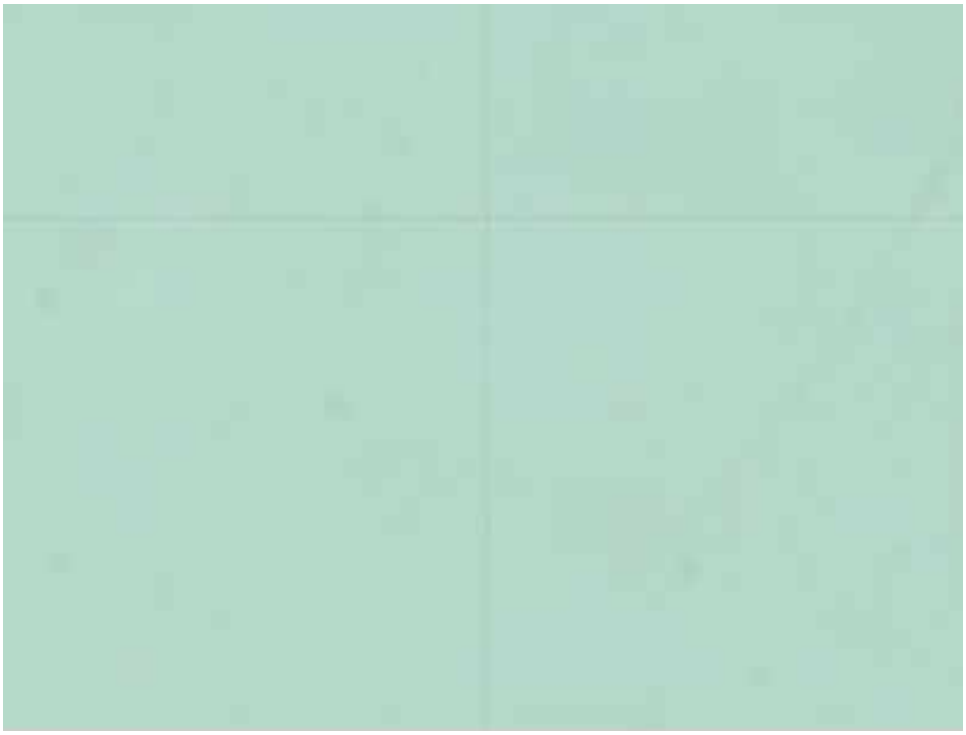
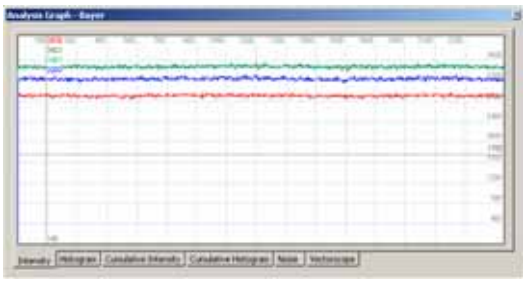


**Figure 13: After LC Intensity Graphs**



After LC Intensity Graph (horizontal)

After LC Intensity Graph (vertical)



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## Verification

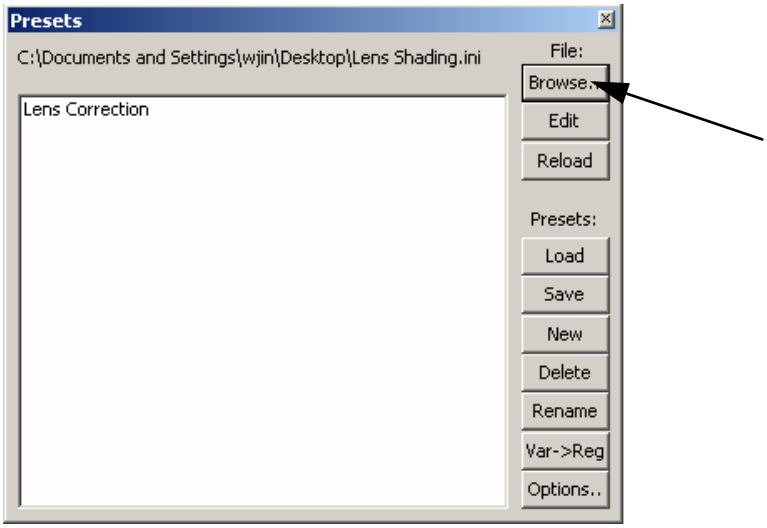
For a thorough verification of lens corrected image results, the following steps are recommended:

1. Place the MT9T013 camera module in front of flat and uniformly illuminated targets for inspection. The following scenarios are suggested: daylight (6500K), incandescent (2850K), cool white florescent (4150K).
2. Load DevWare and reset all registers.

**Figure 14: DevWare**


3. Open Preset window, click on "Browse…" and locate the lens correction .ini file. Enable LC by setting R0x3780 bit[15] to “1.”

**Figure 15: Lens Correction Preset**




4. For each of the scenarios, look at the picture for visual artifacts and the intensity graph to see if a flat curve is obtained for each color (R,G,B).
5. Point the camera module at a well-lit scene and inspect the picture as a last check on image quality.



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# Conclusion

For additional information on lens shading correction, or for more information on other features, refer to the MT9T013 data sheet on Micron's Web site at www.micon.com/imaging.



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# Revision History

**Rev. B** . . . . . **06/05/2007**

- Update Figure 9: “Curve Percentage,” on page 8

**Rev. A** . . . . . **05/30/2007**

- Initial release

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