

TN-09-123: MT9T013 Lens Shading Correction Introduction

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:

$$S_{o}(x,y,c) = S_{i}(x,y,c)^{*}G(x,y,c)$$
 (EQ 1)

Figure 2: Before and After Signal



Products and specifications discussed herein are for evaluation and reference purposes only and are subject to change by Micron without notice. Products are only warranted by Micron to meet Micron's production data sheet specifications. All information discussed herein is provided on an "as is" basis, without warranties of any kind.



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.



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

Sensor Control		X
Sensor Control Data Interpretation SW Color Correction Exposure Auto Exposure White Balance Matrix Buddy Lens Correction Lens Regions Corner Switch Analysis Bands Noise and Defects Output Size Still Capture Diagnostics	White Balance and Color Correction White Balance and Color Correction Adjust Relative Grain Manual Fluorescent Fluorescent Fluorescent Fluorescent I.02 Relative Blue I.04 Current Current Current Current Current I.05 I.20 0.30	X
Refresh	-0.67 2.40 -0.73 -0.38 -2.11 3.54	



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

Sensor Control		×
 Data Interpretation SW Color Correction Exposure Auto Exposure White Balance Unise and Defects Green Balance Output Size Still Capture Diagnostics 	Lens Correction Optical Center Center Overlay 1028 764 Find Optical Center Calibration Point the camera at flat, white surface and set the sensor to full or half resolution mode. Allowed Falloff: 85% Calibrate Lens Correction Save As	
Refresh	Display values in hex	

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.



TN-09-123: MT9T013 Lens Shading Correction Lens Calibration Procedure

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**



Intensity Histogram Cumulative Intensity Cumulative Histogram Noise Vectorscope



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

Options	2
Demo Board Master Clock 72.000 MHz Apply Detect Allow Sensor FPS Polling	Log File Severe Error Minor Error Log Debug (verbose!) View Log
Sensor Base Address	Debug Settings Debug Mode (show dropped frames)
Sensor Output 2048 × 1536 Apply	Test Register Reads ?
Pixel Format: Bayer 10	Miscellaneous Probe for Devices at Startup
Display	Test-Record Mode for Log Dialog
No DirectDraw (Remote Desktop)	Save Last Session in Presets
DirectDraw backbuffer (default) Accelerated (best performance)	Register Dialog Auto Refresh Every Sec.
Warning Dialogs Image: Detect Bad Frame Sequence Reset	Reset All

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.



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.



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)

A Decourse	and the second second second	and the second s
		AND A DOCTOR
		and the second sec
	-	

Before LC Intensity Graph (vertical)



Figure 12: After LC Image



Figure 13: After LC Intensity Graphs



After LC Intensity Graph (horizontal)



After LC Intensity Graph (vertical)

Micron Confidential and Proprietary



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

MI-3130 (MT9T013) MICRON PROPRIETARY - INTERNAL US	SE ONLY		
Eile <u>V</u> iew <u>Plug-ins</u> Command <u>S</u> elect <u>H</u> elp			
📱 📳 🔛 🔲 💭 M P&P 👁		🚗 🖂 🔍 🔍	९ 🏹 🐞
info contru preset egister Log graphs magnify peekpoke watch	options play pause stop reset ended t	fullauto preview capture record zoomin	zoomovt fullscreen report

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

Presets	×
C:\Documents and Settings\wjin\Desktop\Lens Shading.ini	File:
	Browse.
Lens Correction	Edit
	Reload
	Presets:
	Load
	Save
	New
	Delete
	Rename
	Var. >Deg
	Options

- 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.



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.



Revision History

Rev. B	
	Update Figure 9: "Curve Percentage," on page 8
Rev. A	
	Initial release



8000 S. Federal Way, P.O. Box 6, Boise, ID 83707-0006, Tel: 208-368-3900 prodmktg@micron.com www.micron.com Customer Comment Line: 800-932-4992 Micron, the M logo, the Micron logo, and DigitalClarity are trademarks of Micron Technology, Inc. All other trademarks are the property of their respective owners.