IMPERX

APPLICATION NOTE

AN-L04

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LYNX CAMERA SERIES

DUAL FLAT FIELD CORRECTION

Abstract: **This application note describes how to create and use Flat Field Correction files. This note applies to both CameraLink and GigE LYNX cameras.**

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1 Introduction

A CCD imager is composed of a two-dimensional array of light sensitive pixels. Each pixel within the array, however, has its own unique light sensitivity characteristics. Most of the deviation is due to the difference in the angle of incidence and to charge transport artifacts. This artifact is called 'Shading' and in normal camera operation should be removed. The process by which a CCD camera is calibrated for shading is known as 'Flat Field Correction'. Refer to Figures 1 and 2 for images acquired before and after Flat Field Correction.

The Lynx series of cameras incorporate a Flat Field Correction mechanism. The Flat Field Correction mechanism measures the response of each pixel in the CCD array to illumination and is used to correct for any variation in illumination over the field of the array. The optical system most likely introduces some variation in the illumination pattern over the field of the array. The flat field correction process compensates for uneven illumination, if that illumination is a stable characteristic of each object exposure.

During factory final testing, our manufacturing engineers run a program specially designed to identify the shading characteristics of the camera. The program creates a Flat Field Correction file, which contains coefficients describing these shading characteristics. This file is then uploaded into the camera's non-volatile memory. When Flat Field Correction is enabled, the camera will use the Flat Field Correction coefficients to compensate for the shading effect. Flat Field Correction is enabled by the user issuing an '*sfc on*' (Set Flatfield Correction – On) command.

Each Imperx camera is shipped with the Flat Field Correction file that was created for that camera during factory final testing. Users may wish, however, to create their own Flat Field Correction file because of the uniqueness of their operating environment (i.e. lens, F-stop, lighting, etc.). Therefore, Imperx provides a Flat Field Correction utility that allows users to generate a Flat Field Correction file. This file can then be uploaded into the camera. This application note describes how to use the Imperx FFC Processor utility.

NOTE: Flat Field Correction is supported only in the IPX-2M30, IPX-2M30H, IPX-4M15, IPX-11M5 and IPX-16M3 series of cameras.

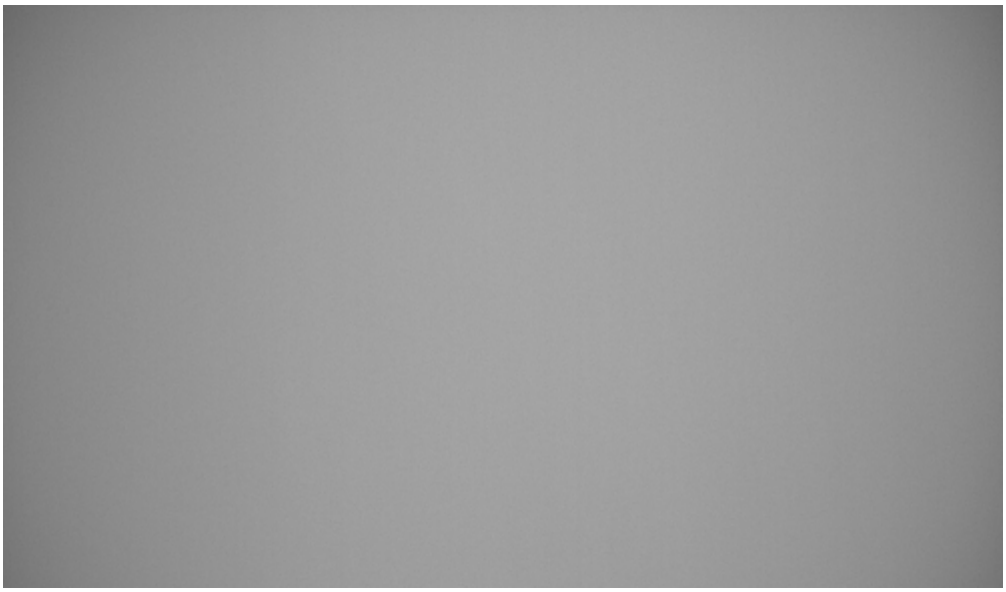

Figure 1 – Original image showing ‘shading’ effect

Figure 2 – Flat Field corrected image

2 Procedure

There are five steps required to perform Flat Field Correction:

1. Create a TIFF or RAW file of an image from the camera
2. Create a TIFF or RAW file of a dark reference image from the camera
3. Run the FFC Processor program and create an FFC file
4. Upload the FFC file into the subject camera
5. Enable FFC processing in the camera

Step1 requires that the user create a sample TIFF or RAW file of an image acquired by the subject camera.

Step 2 requires that the user create a sample TIFF or RAW file of a dark reference image acquired by the subject camera.

Step 3 requires that the user invoke the FFC Processor program to analyze the input files and create a set of Flat Field Coefficients (FFC file).

Step 4 requires that the user upload the FFC file into the subject camera. Note that the FFC file is stored in the camera's non-volatile memory.

Step 5 requires that the user enable FFC correction in the camera. FFC correction can be enabled or disabled at any time by issuing commands to the camera.

2.1 Creating a TIFF or RAW file

Most frame grabbers are capable of capturing images and storing them as either a TIFF or RAW file. Please refer to your frame grabber's users manual.

Before saving an image, make sure that the camera is set to the 12 bit single tap mode (although dual tap will work just as well). Focus the camera on a uniform white target. Make sure to illuminate the CCD with a light pattern that is as representative of the background illumination as possible. This illumination should be bright enough, or the exposure made long enough, so that the CCD pixels signals are at least 25 percent of full scale (for 12 bit mode the level should be at least 1000 ADUs).

The TIFF or RAW file will be used by the FFC Processor utility to create a set of Flat Field coefficients (i.e. FFC file). The FFC file can then be loaded into the camera and used by the camera when Flat Field Correction is enabled.

IMPORTANT NOTE:

If the user changes the operating environment (i.e. lens, lighting, etc), then it may be necessary to create another TIFF or RAW file and repeat the above procedure.

2.2 Creating a dark reference TIFF or RAW file (optional)

Before saving a dark reference image, make sure that the camera is set to the 12 bit single tap mode (although dual tap will work just as well). Completely close the iris on the lens.

The dark reference TIFF or RAW file will be used by the FFC Processor utility as an indicator of the dark noise level. The FFC Processor utility will then remove this dark reference level from the Flat Field coefficients (i.e. FFC file) that it generates.

2.3 Creating a Flat Field Correction File

The 'FFC Processor' utility is a stand-alone program provided by Imperx that allows a user to create Flat Field Correction files. As an input, the utility accepts an image in either a TIFF or RAW format and optionally a dark reference image. Most standard frame grabbers are capable of generating such TIFF or RAW files. The utility performs the following functions:

- Opens a TIFF or RAW image file.
- Opens a TIFF or RAW dark reference image file (this is optional).
- Displays the image and histogram.
- Creates a set of Flat Field Correction coefficients.
- Applies a Flat Field Correction algorithm to the input image using the coefficients. This is the same algorithm implemented inside the camera.
- Displays the resultant image and histogram.
- Allows the user to save the Flat Field Correction coefficients as a file for later upload into the subject camera.

The main window of the FFC Processor is illustrated in Figure 3.

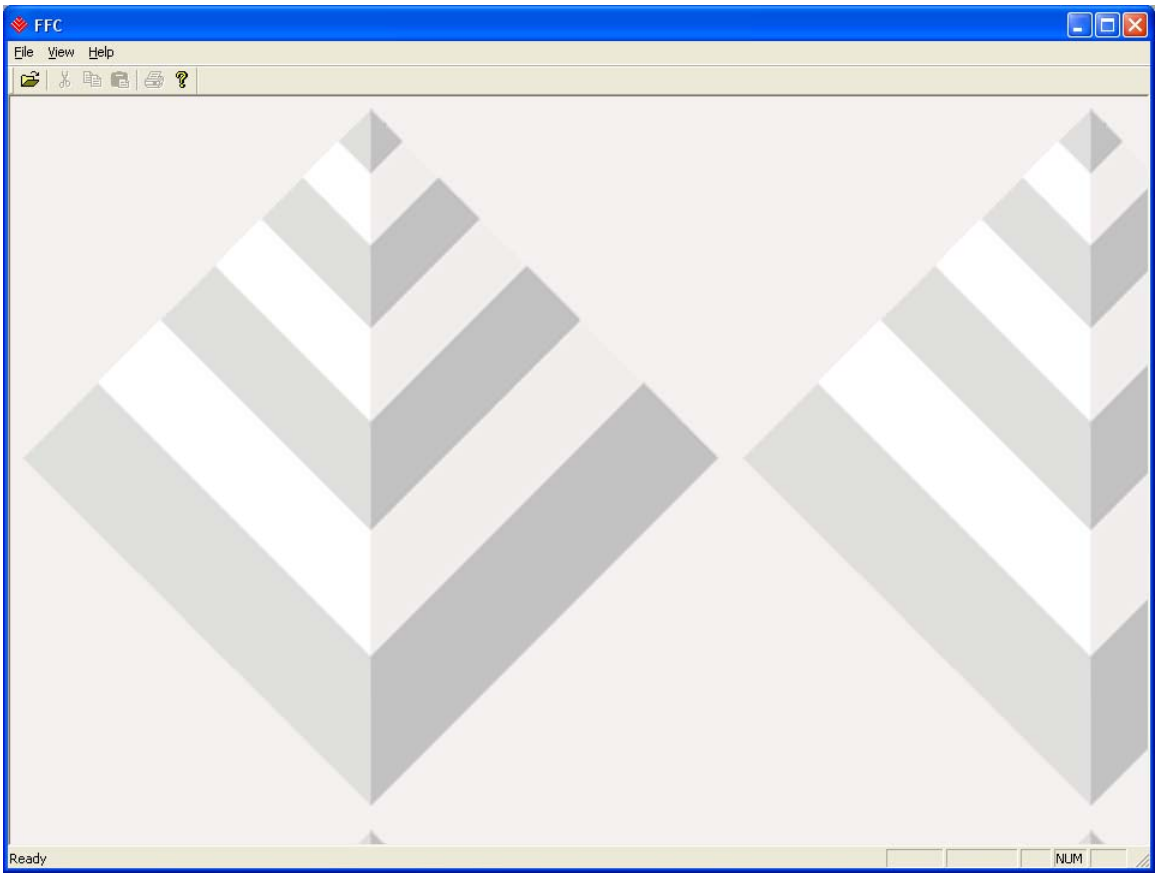

Figure 3 – FFC Processor main dialog

To open a source image, click on ‘File’ and then ‘Open…’ from the top level menu. Browse to the source image file and click ‘Open’. The ‘Image Information’ dialog will appear – Figure 4. This dialog summarizes the image’s attributes.

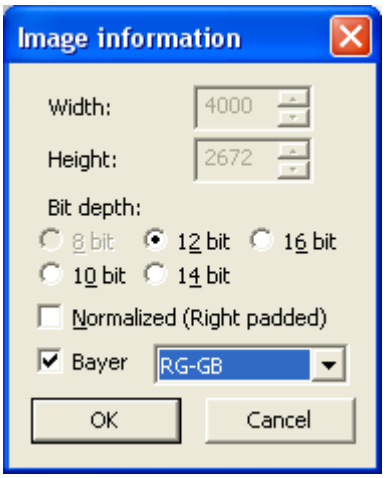

Figure 4 – Image information dialog

Select ‘Normalized (Right padded)’ if your frame grabber creates 16 bit TIFF/RAW files where the 12 bit pixel data is left justified (i.e. 4 LSBs are set to zero). Deselect ‘Normalized (Right padded)’ if your frame grabber creates 16 bit files where the 12 bit pixel data is right justified (i.e. 4 MSBs are set to zero).

For example: TIFF/RAW word is d15..d0 and Pixel data is p11..p0

Normalized selected (right padding) :

d15	**d14**	**d13**	**D12**	**d11**	**d10**	**d9**	**d8**	**d7**	**d6**	**d5**	**d4**	**d3**	**d2**	**d1**	**d0**
p11	p10	p9	P8	p7	p6	p5	p4	p3	p2	p1	p0	0	0	0	0

Normalized not selected (left padding) :

d15	**d14**	**d13**	**D12**	**d11**	**d10**	**d9**	**d8**	**d7**	**d6**	**d5**	**d4**	**d3**	**d2**	**d1**	**d0**
0	0	0	0	p11	p10	p9	p8	p7	p6	p5	p4	p3	p2	p1	p0

Select ‘Bayer’ if the RAW file contains Bayer encoded pixels from a Bayer color camera. Choose the appropriate Bayer pattern, RG-GB, GR-BG, BG-GR or GB-RG, from the pull-down menu.

After clicking the ‘OK’ button, the utility will open a second dialog titled ‘Open Dark Image’. Browse to the dark reference file and click ‘Open’. If there is no dark reference file then simply click ‘Cancel’.

The utility will process the images and create a set of FFC coefficients. It will then display the original image and it’s histogram in the top panel and the post-FFC processed image and it’s histogram in the bottom panel – Figure 5. The histogram includes two plots: 1) the average pixel value (Y-axis) versus column position (X-axis) and 2) the average pixel value (Y-axis) versus row position (X-axis).. Note that the algorithm that the utility uses to ‘correct’ the original image, using the FFC coefficients generated, is the same algorithm that is implemented inside the camera. Therefore, the results that you get with the FFC Processor utility will be identical to the results that you will receive with the camera.

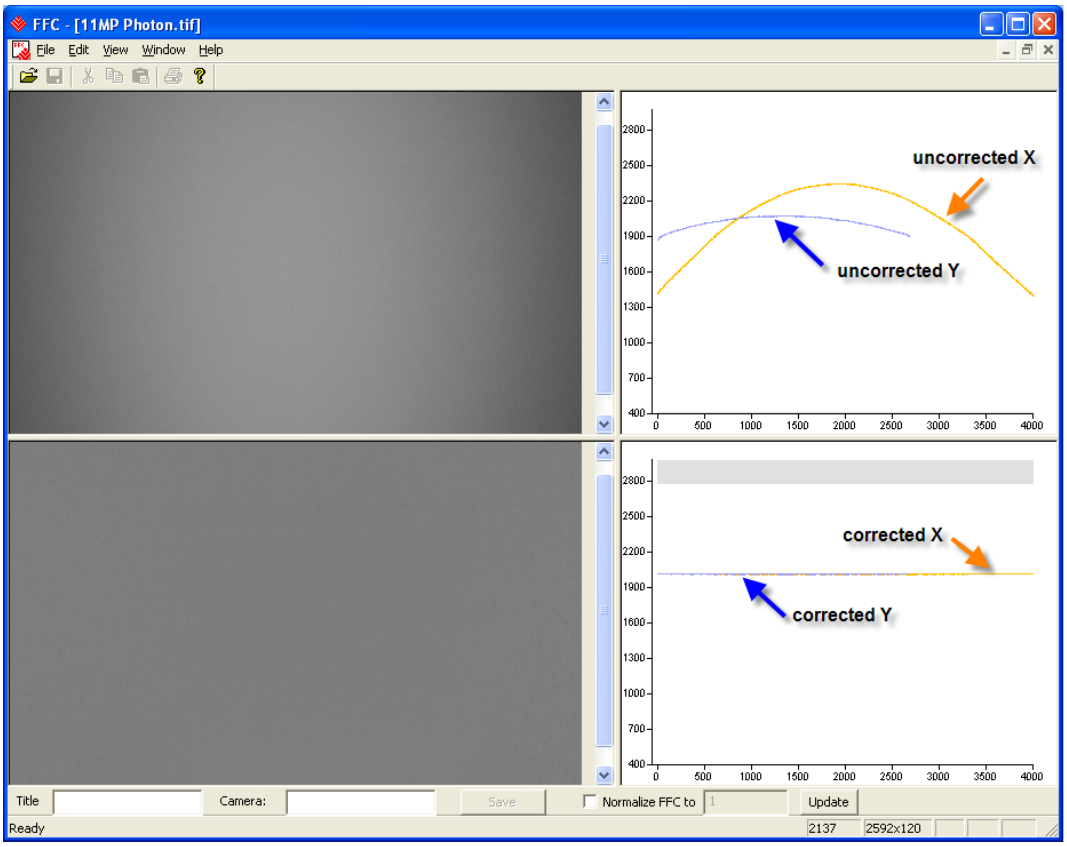

Figure 5 – Image and histogram display

To change the scale of the image, click on ‘View’ and then ‘Zoom’ from the top level menu.

The user can enter text into the ‘Title’ and ‘Camera’ fields. This text will be included in the FFC file and is the text that gets displayed when issuing a ‘gfh’ (Get Flatfield Header) command. Note that the ‘date’ is automatically entered into the FFC header. To save this FFC file to your disk drive, click on the ‘Save’ button.

2.4 Uploading a Flat Field Correction File into a camera

The Flat Field Coefficients (FFC file) created by the FFC Processor program can be uploaded into the camera using the Imperx Lynx Terminal utility. Please refer to application note AN_L01 for instructions on how to use the LynxTerminal utility.

2.5 Enabling Flat Field Correction

The camera supports three commands related to Flat Field Correction processing: '**sfc**', '**gfc**' and '**gfh**'.

Set Flatfield Correction ('sfc')

The `'sfc'` command instructs the camera to perform the Flat Field correction procedure. During this procedure, the camera reads a set of flat field coefficients from on-board non-volatile memory. It uses these coefficients to compensate for any variations in the pixel responsivity.

Syntax:	`sfc <on|off>`	
Parameter:	`on`	Enable Flat Field correction processing.
	`off`	Disable Flat Field correction processing.
Example:	`sfc on`	Enable Flat Field correction.

Notes: Flat field correction is only supported in the IPX-2M30, IPX-2M30H, IPX-4M15, IPX-11M5 and IPX-16M3 series of cameras.

The Flat field file is loaded into the same non-volatile memory as LUT #2.

Flat field processing and lookup table processing are mutually-exclusive.

Get Flatfield Correction ('gfc')

The `'gfc'` command returns the current flat field correction setting.

Syntax:	`gfc`	
Response:	`on|off`	
Example:	`gfc`	User enters command.
	`on`	Camera responds with current setting.

Get Flatfield Header ('gfh')

The `'gfh'` command returns the text header information in the Flat Field Correction file.

Syntax:	`gfh`	
Response:	`Flat field file header text`	
Example:	`gfh`	User enters command.

	`FFC file for IPX-11M5-L`
	`Serial# 123456`
	`date 3/29/06`
		Camera responds with Flat Field header text.