IMPERX

APPLICATION NOTE

AN-L05

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LYNX CAMERA SERIES

DEFECTIVE PIXEL CORRECTION

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

Imperx, Inc.
Tel: (+1) 561-989-0006
Fax: (+1) 561-989-0045
Email: techsupport@imperx.com
Web: www.imperx.com

1 Introduction

A CCD imager is composed of a two-dimensional array of light sensitive pixels. In general, the majority of the pixels have similar sensitivity. Unfortunately, due to fluctuations in the CCD manufacturing process, there are some pixels which sensitivity deviates from the average pixel sensitivity. There are three major types of defective pixels – "DARK", "BRIGHT" and "HOT" – Figure 1.

1. "DARK" is defined as a pixel, whose sensitivity is lower than the sensitivity of the adjacent pixels. In some cases this pixel will have no response (completely dark).
2. "BRIGHT" is defined as a pixel, whose sensitivity is higher than the sensitivity of the adjacent pixels. In some cases this pixel will have full response (completely bright).
3. "HOT" is defined as a pixel, which in normal camera operation behaves as normal pixel (the sensitivity is equal to the one of the adjacent pixels), but during long time integration behaves as a high intensity bright pixel. In some cases this pixel will have full response (completely bright).

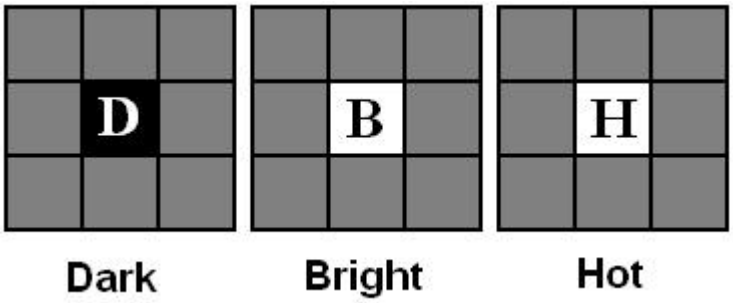

Figure 1. – Defective pixels

The process by which pixel sensitivity is corrected is called "Defective Pixel Correction" (DPC). The Lynx series of cameras incorporate a Defective Pixel Correction mechanism. During factory final testing, our manufacturing engineers run a program specially designed to identify the defective pixels. The program creates a Defective Pixel Map file, which contains the locations of the discovered defective pixels. This file is then uploaded into the camera's non-volatile memory. When Defective Pixel Correction is enabled, the camera will use the DPM to compensate for the defective pixels. The compensation uses the linear interpolation method. The correction is enabled by issuing an '*sdc on*' (Set Defective Pixel Correction – On) command. The user can display the defective pixel map by issuing a '*dpm*' (Dump Pixel Map) command. Due to internal memory limitations, the maximum number of defective pixels is limited to 128.

Each Imperx camera (with the exception of a IPX-VGA120/210) is shipped with the Defective Pixel Map file that was created for that camera during factory final testing. Users may wish, however, to create their own DPM file because of the

uniqueness of their operating environment or camera use. Therefore, Imperx provides a Defective Pixel Correction utility that allows users to generate a DPM file. This file can then be uploaded into the camera. This application note describes how to use the Imperx DPC utility.

NOTE: Defective Pixel Correction is supported in all LYNX Cameras. A Defective Pixel Map is preloaded in all IPX-1M48, IPX-2M30, IPX-2M30H, IPX-4M15 and IPX-11M5 cameras but not in an IPX-VGA120/210. The user can upload his own custom map to IPX-VGA120/210.

2 Procedure

The DPC mechanism is a three-step process. The first step is the creation of the Defective Pixel Map (DPM). The second step is transferring the DPM into the camera, and the last step is enabling the defective pixel correction mechanism.

1. Create a Defective Pixel Map (DPM) file using Imperx' DPC utility. If the user knows the location of the defective pixels (or the user needs to add more pixels), the DPM file can be created (appended) manually as described later.
2. Upload the DPM file into the subject camera. Note that the DPM file is stored in the camera's non-volatile memory.
3. Enable DPC processing in the camera. DPC feature can be enabled or disabled at any time by issuing commands to the camera.

2.1 Creating a DPM file

The 'DPC Processor' utility is a program provided by Imperx that allows the user to create Defective Pixel Map files. (For the camera link output versions of LYNX cameras the program is designed to work with the Imperx "FrameLink" PCMCIA Frame grabber. The executable DPC file should be located in the FrameLink folder).

For proper defective pixel discovery, the user needs a uniform light source. This source should have a uniform spectrum (white light), and should be bright enough so that the CCD pixels signals are at least 50 percent of full scale (for 12 bit mode the level should be at least 2000 ADUs). To create the DPM file, use the following steps:

- Open DPC utility software – Figure 2. Click on the "Camera" menu and select the "Camera Configuration". A new window will appear – Figure 3. Set the camera parameters. The default is full image window, 12-bit, dual, no LUT, but the user can set the parameters to any desired values.

- Set the camera to free running mode, or to the mode the camera will be used. To set/change the camera configuration (mode of operation), click on “Help” menu and select “LYNX Terminal Dialog” A new window will appear – Figure 4, where the user can enter the required camera configuration commands. When completed, press “Start Grab” button.
- Illuminate the camera with a uniform light source, so the signal level in the display window is ~ 2000 ADU for 12 bit mode (~ 500 ADU for 10 bit mode and 130 ADU for 8 bit mode).
- To find and record the dark pixels enable “Dark” box, and set the threshold slider to 400 ADU, i.e. approximately 10% of the maximum signal value (~ 100 ADU for 10 bit mode and 25 ADU for 8 bit mode). The user can set the threshold value to any desired level. Click on “Start test” button, and the list of the dark pixels will appear in the window.
- To find and record the bright pixels enable “Bright” box, and set the threshold slider to 3600 ADU, i.e. approximately 90% of the maximum signal value (~ 900 ADU for 10 bit mode and 230 ADU for 8 bit mode). The user can set the threshold value to any desired level. Click on “Start test” button, and the list of the bright pixels will appear in the window.

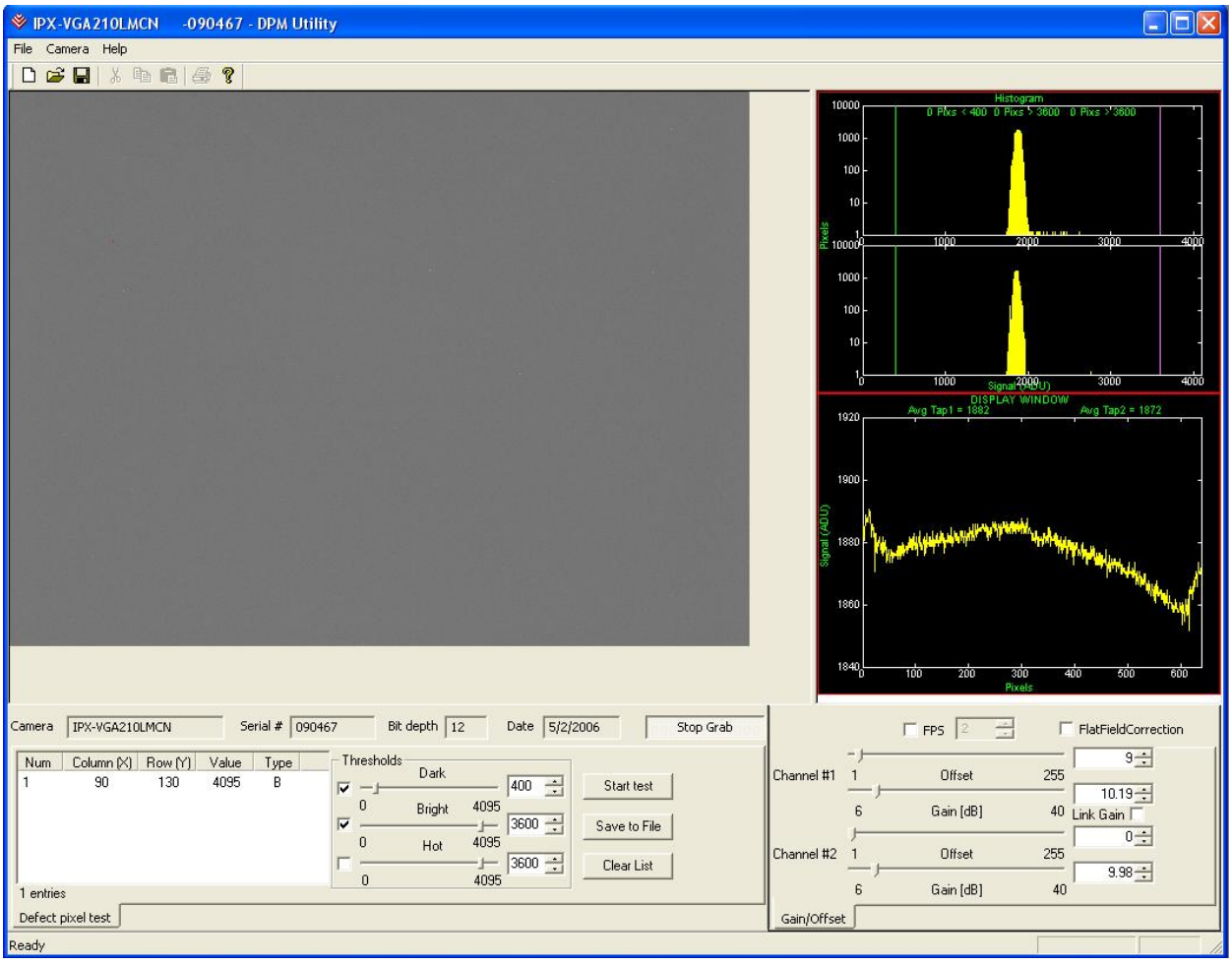

Figure 2 – DPC Processor main dialog

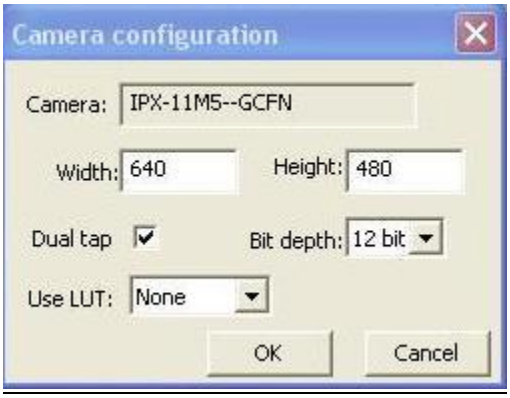

Figure 3 – Camera Configuration window

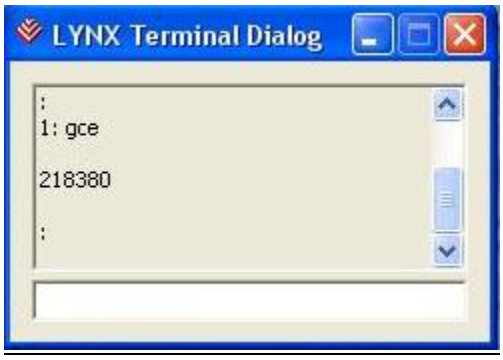

Figure 4 – LYNX Terminal Dialog window

- To find and record the hot pixels the user first needs to set the camera to high gain ~ 30 dB. Reduce the camera illumination, so the signal level in the display window is ~ 100 ADU (or less) for 12 bit mode (~ 25 ADU for 10 bit mode and 10 ADU for 8 bit mode). Enable "Hot" box, and set the threshold slider to 3600 ADU, i.e. approximately 90% of the maximum signal value (~ 900 ADU for 10 bit mode and 230 ADU for 8 bit mode). The user can set the threshold value to any desired level. Click on "Start test" button, and the list of the hot pixels will appear in the window. For this test the user can use long integration. Using the dialog window (Figure 4) set the camera to 500 ms long integration (type ***sli 500*** in the dialog window) and repeat the test.
- At any point during the tests, the user can clear the defective pixel list and start over.
- This completes the test. Click on the "Save to file" button, and the utility will create the DPM file for later upload into the subject camera.

2.2 Manually editing the DPM file

The Defective Pixel Map (DPM file) created by the DPC Processor program can be manually edited if the user needs to add (or delete) pixels, which were not discovered by the DPM Processor. Open the DPM file (the file extension is .dpm) with "Notepad" or any other editing software. The file looks like this:

```
-- Date: 4/21/2006,
-- Model#: IPX-2M30--LCCN     ,
-- Serial#: 060380,
:Table,
-- Column(X),Row(Y)
1564,1
1588,1
1578,5
1582,27
1580,31
1115,42
```

All pixels are listed in the DPM in order of increasing Y location. If the Y location is identical, the listing is in order of increasing X location. After editing save the file. The maximum number of pixels in the list is 128.

Example.

1. Add a pixel (100, 35). This pixel has to be inserted after pixel (1580, 31).
2. Add a pixel (1570, 1). This pixel has to be inserted between pixels (1564, 1) and (1578,1).

2.3 Uploading a Defective Pixel Map file into a camera

The Defective Pixel Map (DPM file) created by the DPC 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.

2.4 Enabling Defective Pixel Correction

The camera supports three commands related to Defective Pixel Correction processing:
'**sdc**', '**gdc**' and '**dpm**'.

Set Defect Correction ('sdc')

The `'sdc'` command instructs the camera to perform the defective pixel correction procedure. During this procedure, the camera reads the location

of the defective pixels from on-board non-volatile memory and makes the correction.

Syntax:	`sdc <on|off>`	
Parameter:	`on`	Enable defective pixel correction.
	`off`	Disable defective pixel correction.
Example:	`sdc on`	Enable defective pixel correction.

Get Defect Correction ('gdc')

The `'gdc'` command returns the current defective pixel correction setting.

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

Dump Pixel Map ('dpm')

The `'dpm'` command returns the map (location) of all recorded defective pixels as listed in the Defective Pixel Map file.

Syntax:	`dpm`	
Response:	`List of the locations of all defective pixels.`	
Example:	`dpm`	User enters command.
		Camera responds with Defective Pixel Map – Figure 5:

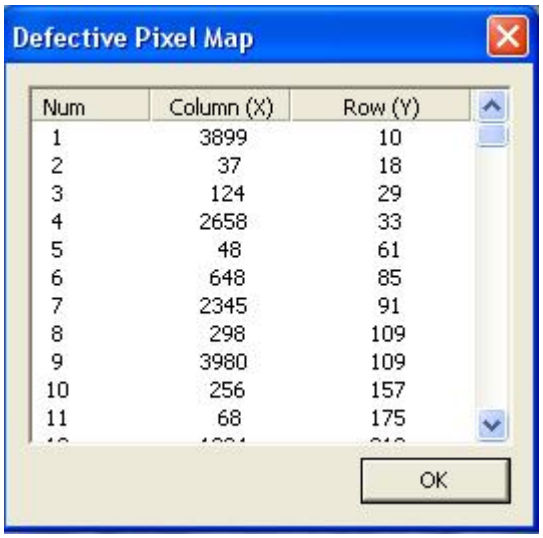

Figure 5. Defective Pixel Map window