Defective pixel specification of the VD55G1

Introduction

This document provides an overview of the EWS defect specification for the VD55G1 global shutter image sensor optimized for near infrared scenes. The sensor captures up to 168 frames per second in an 804 x 704 resolution format.

The device is a 0.5 megapixels global shutter image optimized for near infrared scenes. Table below outlines key device parameters.

Table 1. **Key device parameters**

Parameter	Description
Pixel size	2.61 µm x 2.61 µm
Pixel resolution	808 x 708 pixels (including borders)
Die size	2.73 x 2.16 mm
Sensor technology	3D stacked
Shutter	Global
Analog gain	x1 to x8
ADC resolution	10 bits
Frame rate (at full resolution)	Up to 168 fps in 10bits full resolution
CSI-2 serial interface data rate	Up to 1.2 Gbp/s
Pixel output format	RAW8 or RAW10
Power supply (Min./Typ./Max.)	AVDD: 2.7/2.8/2.9 V VDDIO: 1.62/1.8/1.92 V DVDD: 1.05/1.1/1.26V
External clock frequency range	6 MHz to 27 MHz, DC coupled
Operating temperature (Tj)	-30°C to +85°C (functional)
Temperature sensor accuracy	±2°C in the range [25°C; 105°C]

1 Acronyms and abbreviations

Table 2. **Acronyms and abbreviations**

Acronym/abbreviation	Definition
ADC	analog-to-digital converter
AVDD	analog supply voltage (VDDA)
DVDD	digital supply voltage (Vcore)
EWS	electrical wafer sort
fps	frames per second
LED	light emitting diode
LSB	least significant bit
ppm	parts per million
VDDIO	IO supply voltage

2 Test conditions

2.1 Voltage supplies

During defective pixel testing, the sensor used the nominal supply voltages shown in the table below.

Table 3. Nominal supply voltages

Supply voltage	Value used
DVDD	1.2 V
VDDIO	1.8 V
AVDD	2.8 V

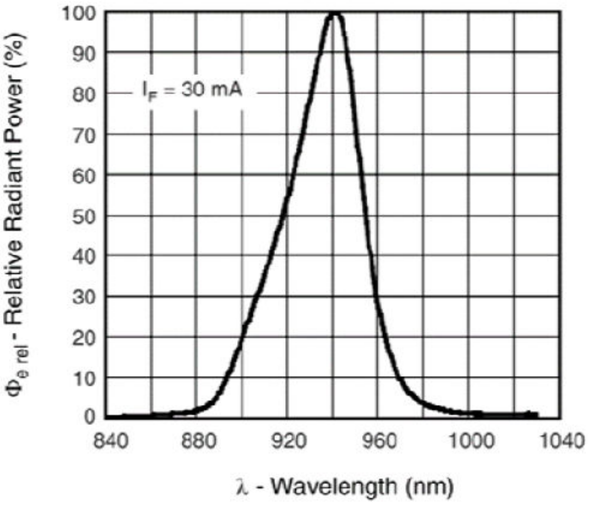
2.2 Light sources

During testing, the following LED panel with the following characteristics is used.

Table 4. Characteristics of light sources

Parameter	LED
Maximum intensity	100 μW/cm^2
Intensity accuracy	±5%
Light area	80 mm x 100 mm
Uniformity	±3%

Figure 1. Relative radiant power vs. wavelength



2.3 Temperature

The test temperature is fixed by the prober chuck at $T_{Junction}$ = 60°C.

2.4 Image readout and capture settings

Table 5. **Image readout settings**

Parameter	Setting
Full resolution	808 x 716
Visible data	804 x 704
Dark lines	8
Borders	Always on (4 rows and columns)
Defect correction	Always off

Note: All the capture settings (including dark lines, visible data, and the borders) are for a full resolution of 808x716. But, the algorithms are applied on the visible data (including the borders) only for an image resolution of 808x708.

3 Defective pixel specification

Images are captured in different lighting conditions. The images are then analyzed with a defect detection algorithm.

3.1 Capture definition

Defectivity is tested in dark and light conditions with the **image correction included in the IP deactivated**.

Table 6. **Image capture settings**

Parameter	Dark capture	Light capture
Light power	Off	19 µW/cm² (1)
Supplies	Nominal	Nominal
Integration time	10 ms	12 ms
Analog gain	4	1
Digital gain	1	1
Dark calibration	Off	On (with pedestal at 0)
Number of frames	16	5

1. *The light capture is done using infrared light source to reach roughly 70% of the maximum code (720 LSB) in the center.*

3.2 Defectivity algorithms

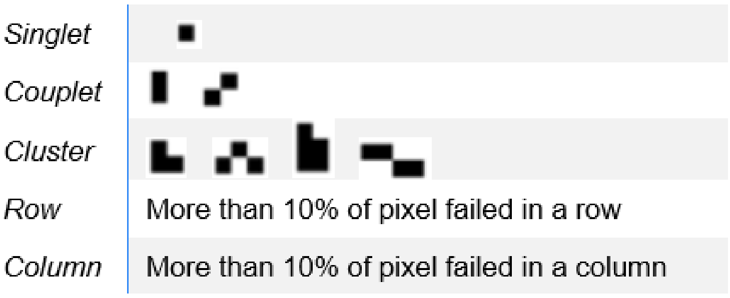
The purpose of this algorithm is first to detect defect pixels, then to categorize them.

The pixels that highlight significant deviation compared to a localized pixel mean can be calculated in absolute value (for captures without light) or using a percentage (for captures in light).

- Local pixels mean value are calculated using a flat kernel of 41x41.
- Each time a pixel differs from the local mean by an absolute value or a relative threshold, the pixel is identified as “failing pixel” and a corresponding fail map is generated for future fail categorization process.

Once the defect map is generated, the defect categorization algorithm sorted the failed pixels to detect single pixels, couplets, clusters, rows, and columns issues.

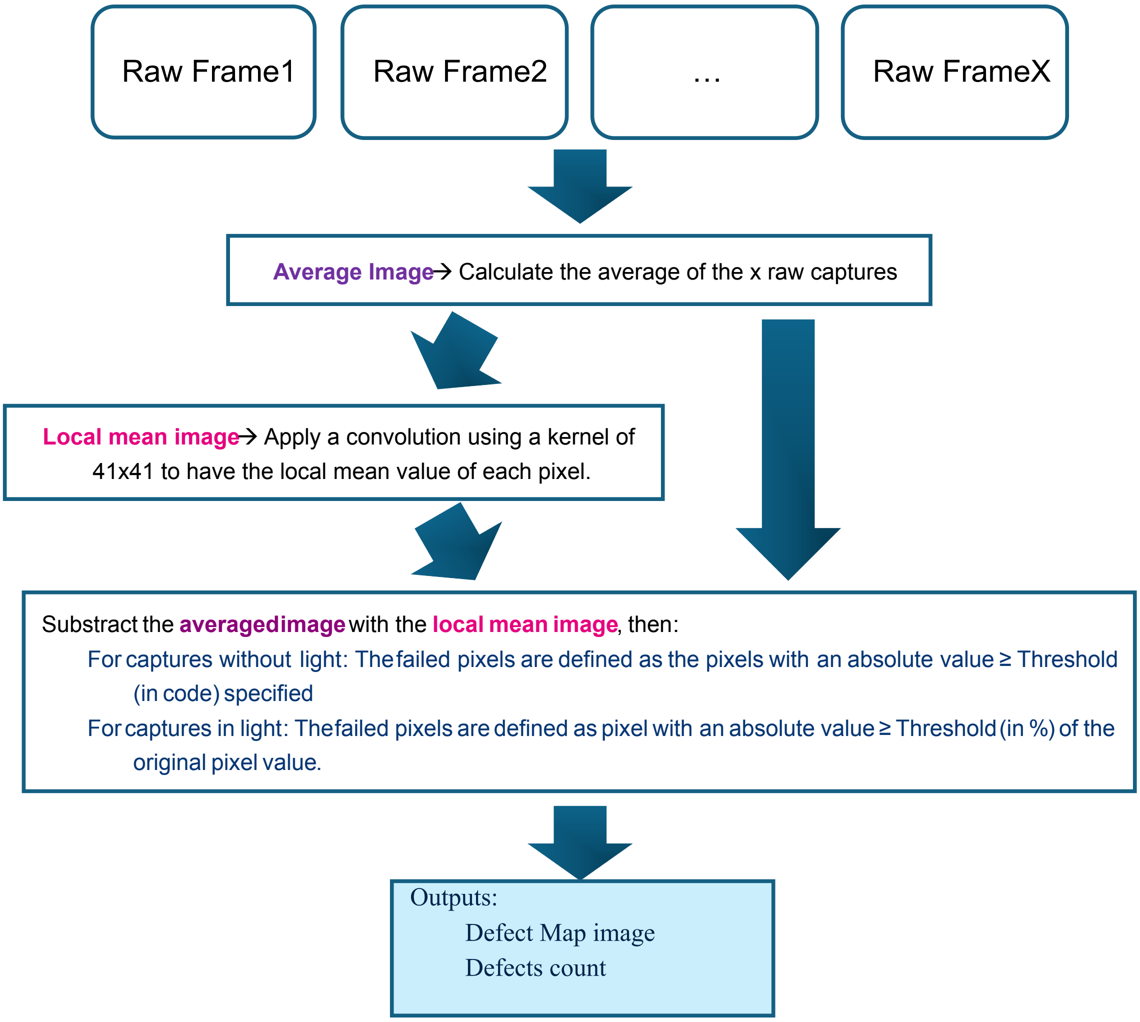
Figure 2. **Categorization of failed pixels**



More than 10% of pixel failed in a row

More than 10% of pixel failed in a column

Figure 3. **Defect detection implementation**



Average Image→ Calculate the average of the x raw captures

Local mean image→ Apply a convolution using a kernel of 41x41 to have the local mean value of each pixel.

Substract the **averagedimage** with the **local mean image**, then:

For captures without light: The failed pixels are defined as the pixels with an absolute value ≥ Threshold (in code) specified

For captures in light: The failed pixels are defined as pixel with an absolute value ≥ Threshold (in %) of the original pixel value.

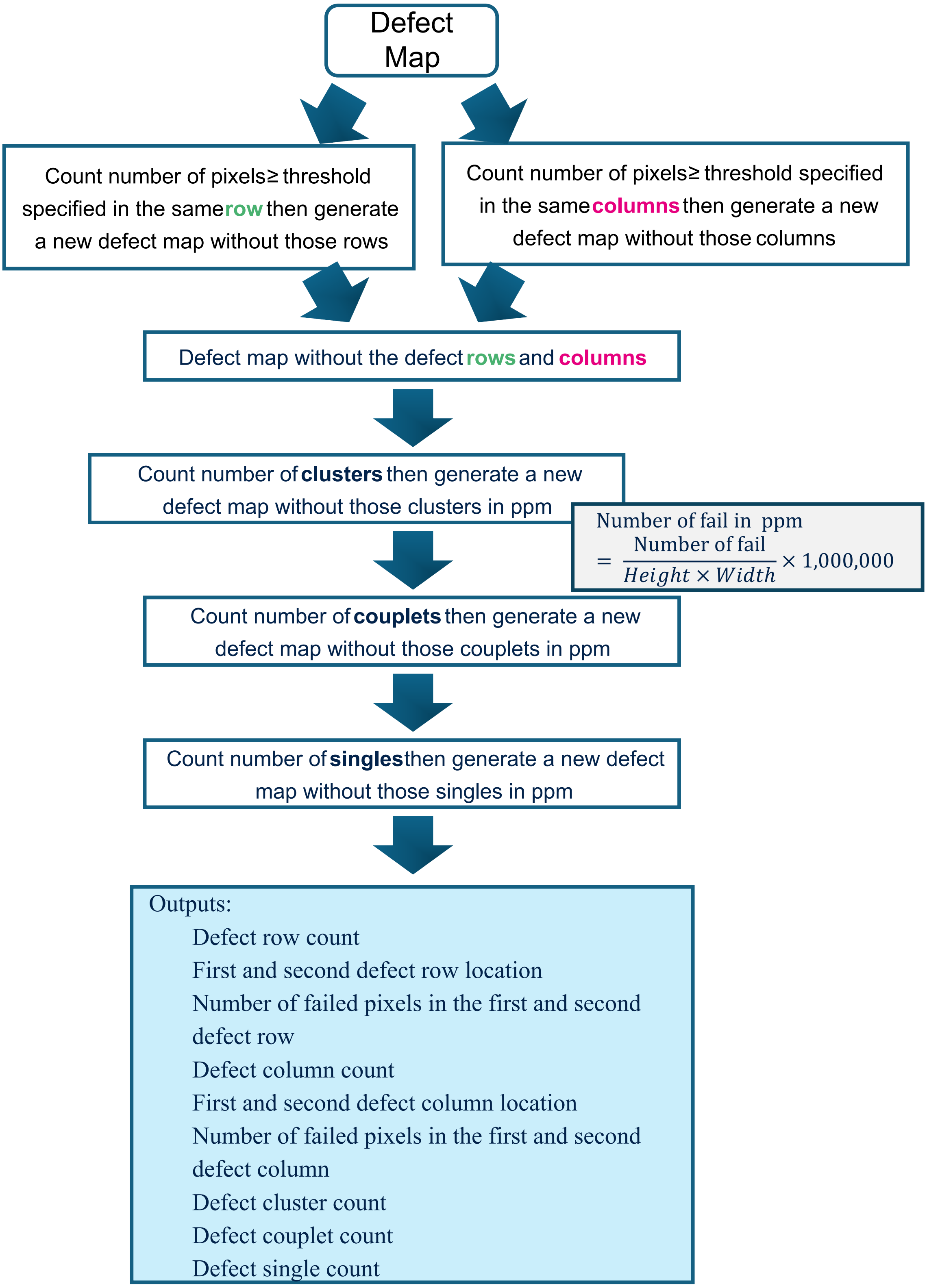
Outputs:
Defect Map image
Defects count

The table below shows the thresholds applied to the dark and light captures.

Table 7. **Dark and light capture thresholds**

Capture	Threshold applied
Dark	±25 codes
Light	±12%

Figure 4. **Defect categorization**



Count number of pixels≥ threshold specified in the same row then generate a new defect map without those rows

Count number of pixels≥ threshold specified in the same columns then generate a new defect map without those columns

Defect map without the defect rows and columns

Count number of **clusters** then generate a new defect map without those clusters in ppm

$$\text{Number of fail in ppm} = \frac{\text{Number of fail}}{Height \times Width} \times 1{,}000{,}000$$

Count number of **couplets** then generate a new defect map without those couplets in ppm

Count number of **singles** then generate a new defect map without those singles in ppm

Outputs:

- Defect row count
- First and second defect row location
- Number of failed pixels in the first and second defect row
- Defect column count
- First and second defect column location
- Number of failed pixels in the first and second defect column
- Defect cluster count
- Defect couplet count
- Defect single count

3.3 Defective limits

Table 8. **Defective limits**

Parameters	Max. defects in the dark	Max. defects in the light
Defective row counts	0	0
Defect column counts	0	0
Defective single counts	150 ppm	33 ppm
Defective couplet counts	20 ppm	13 ppm
Defective cluster counts	0 ppm	0 ppm

$$Number\ of fails\ in\ ppm = \frac{Number\ \ of fails}{Height \times Width} \times 1,000,000$$

Revision history

Table 9. **Document revision history**

Date	Version	Changes
27-Jun-2024	1	Initial release

Contents

IMPORTANT NOTICE – READ CAREFULLY