AN5823

Application note

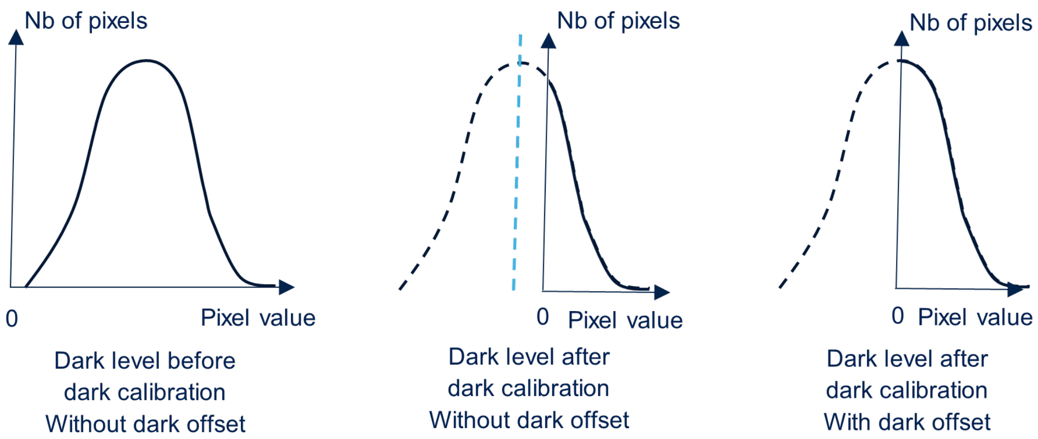
Dark calibration correction for high temperatures on VG5661, VD5661, VG5761, VD5761, VD6763, VG1762, and VD1762

Introduction

Image sensors dark calibration consists in removing the dark current contribution to the pixels. The dark current is estimated from pixels isolated from the light under metal layer. Their average value, measured at each frame, is subtracted from all the active pixels. The isolated pixels are part of the dark lines, and it is assumed that the dark current is the same on dark and active lines.

VG5661, VD5661, VG5761, VD5761, VD6763, VG1762, and VD1762 sensor family has a mismatch of dark current between dark lines and active lines at high imager junction temperatures, above 90°C. The dark current on dark lines is slightly above the one on active lines, which leads to images that are too dark.

Figure 1. Demonstration of need for dark offset compensation above 100°C



In order to compensate this mismatch, and the resulting information loss, a reference dark level value is stored in the sensor non-volatile memory (NVM). This allows to calculate a corrective dark offset.

This document describes how to read the dark level value stored in NVM and how to use it to calculate and apply the corrective dark offset.

1 Read the reference dark level

Description of the reference dark level

The dark level value used as reference for the corrective dark offset calculation is the average pixel level measured on an image center captured under no light, with 12 ms integration time, analog gain x1 and at junction temperature 105°C, with 12 bits per pixel. It corresponds to long frame measurement, but the same value can be used for short frame.

A dark pedestal of 64 is also applied to the image. Which means the dark level is expected to be around 64 for low temperatures (below 90°C), and decreases below 64 for higher temperatures.

This dark level reference value is measured and written in sensor NVM at wafer tests in production.

Readout of the reference dark level

All the NVM content is mirrored to user interface registers. The reference dark level can be found at register EWS_4 available at address 0x714. Only the 12 LSBs are relevant.

The dark level value, with the dark pedestal 64, is coded as follows:

$$Dark\ level = \frac{NVMvalue}{100} + 40$$

The dark level value is expressed in digital number.

2 Check if reference dark level is programmed

For previous samples with reference dark level not programmed in NVM, the default value of the EWS_4 register is zero. This value is forbidden for the reference dark level. Therefore, before performing the dark level correction, you must check if the reference dark level is programmed in NVM. If the value is zero, it means that a sample with non-programmed reference dark level is used: no correction can be performed.

3 Compute dark level correction

Dark level varies with integration time and temperature. Based on the reference dark level read in the sensor NVM, the dark level for any integration time and temperature can be calculated, based on the two following rules:

- Dark level variation with integration time is linear
- Dark level variation with temperature follows a doubling temperature rule, with a doubling every 8.2°C. It is considered that variation with temperature < 90°C is negligible

As a result, the dark level for a temperature in degrees Θ and integration time in milliseconds. T_{int} is calculated as follows:

$$darkLevel\left(T_{\text{int}},\,\theta\right) = 2^{\frac{\theta - 105}{8.2}} \times \frac{referenceDarkLevel(12ms,\ 105\text{deg}C)\ - 64}{12} \times T_{\text{int}} + 64$$

Below 2 ms of integration time, the combination of linearity response versus integration time and doubling temperature response versus temperature is no longer valid. For all integration times below 2 ms, T_{int} = 2 ms must be used.

Then the dark offset to apply to the sensor to compensate for the dark level loss at high temperatures can be calculated as follows:

$$darkOffset\left(T_{\text{int}},\,\theta\right) = darkLevel\left(T_{\text{int}},\,\theta\right) - 64 = 2^{\frac{\theta - 105}{8.2}} \times \frac{referenceDarkLevel - 64}{12} \times T_{\text{int}}$$

4 Set the dark level correction

Once calculated, the dark offset must be written into the sensor registers. This must be done for each image, as integration time and sensor temperature may vary for each frame. It can be done either during standby or streaming operations.

Different registers are available for dark offset control for long and short frames. Both are 8-bit registers that must be filled in directly with the same integer dark offset calculated from NVM value.

For a long frame, register DARKCAL_LONG_PEDESTAL at address 0x456 must be filled in. For a short frame, register DARKCAL_SHORT_PEDESTAL at address 0x457 must be filled in.

The calculated dark offset value corresponds to a 12-bit image bit width. For any other bit width ‘bitsPerPixel’, the dark offset to write into dark pedestal registers is:

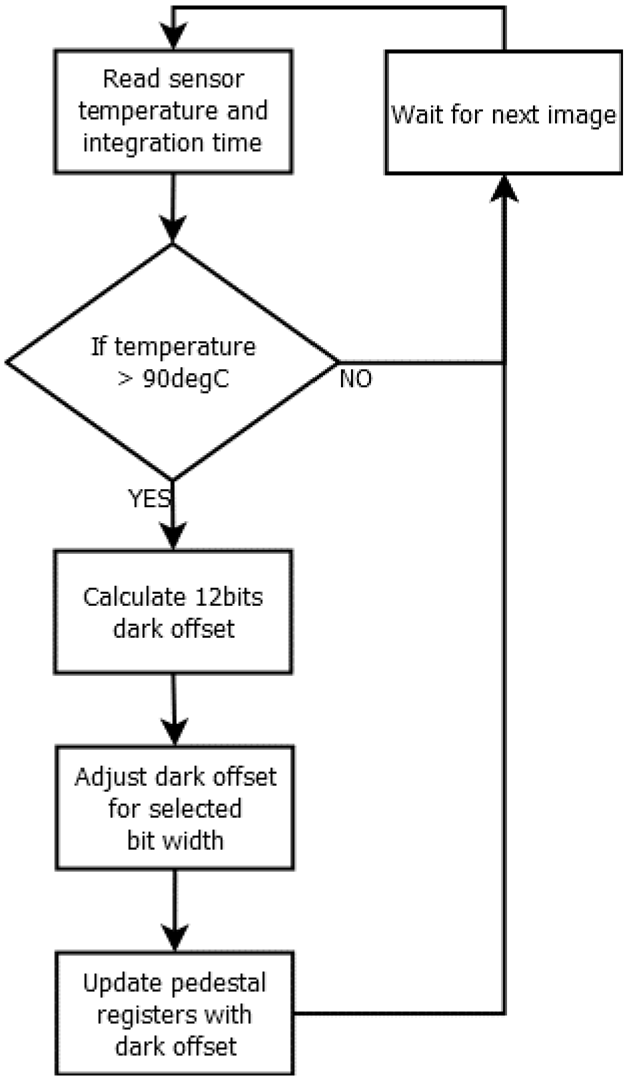
$$darkOffset\left(bitsPerPixel\right) = \frac{darkOffset(12bits)}{2^{12 - bitsPerPixel}}$$

5 Dark calibration correction flow

The first step is to read the reference dark level stored in the NVM. This can be done only once.

The following flow describes the steps to follow to correct the dark level for a given sensor temperature and integration time.

Figure 2. **Dark calibration correction flow**



Revision history

Table 1. Document revision history

Date	Version	Changes
17-May-2022	1	Initial release
20-Jun-2022	2	Added Section 2 Check if reference dark level is programmed

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