Dragster – calibration

Application Note

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Valid for:
Applicable to all Dragster versions

Abstract

The document provides a detailed guide on configuring Dragster sensors by adjusting ADC offset, ADC gain, CDS gain, and integration time registers. It not only explains individual adjustments but also illustrates how these actions can be combined for precise calibration. Through detailed step-by-step instructions and insights, users acquire the knowledge to enhance sensor performance.

Table of contents

1 Introduction

This application note provides an overview of the steps to configure Dragster sensors, aiming to minimize the effects of the mismatch between pixel values and ensuring a consistent linear light response across all over the pixel line, and, consequently, reducing DSNU and PRNU.

2 Sensor calibration

2.1 Setup

In this calibration procedure, the system includes an Evaluation Board[1] (communication over Camera Link), the Dragster sensor DR16K3.5 and the Dragster Viewer communication software. Despite the focus on this sensor variant, the process remains comparable across other sensors.

The illumination source is a white LED.

All communication with the sensor occurs through RS232 serial communication.

[1] For further details about the evaluation board, please refer to the user guide manual - Dragster_UG000306.

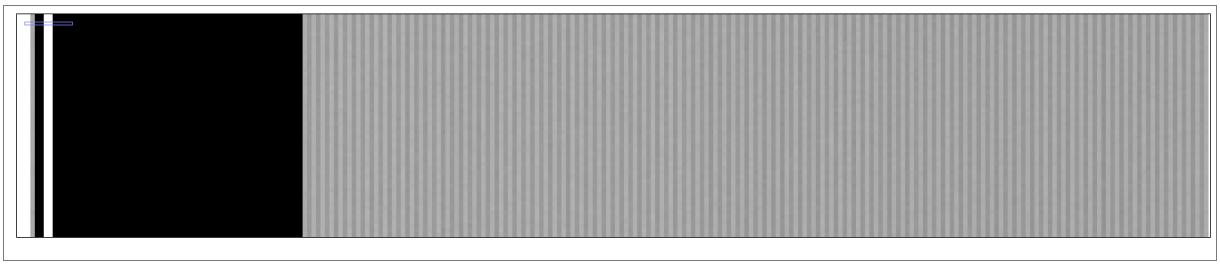
2.2 Calibration

The calibration's ultimate goal is to fine-tune the ADC offset (register 0x04)[2] and gain (register 0x03), achieving a uniform image output from the sensor.

This process involves two essential steps: An initial calibration without light, followed by a subsequent calibration with light at approximately 80% ADC sensor saturation.

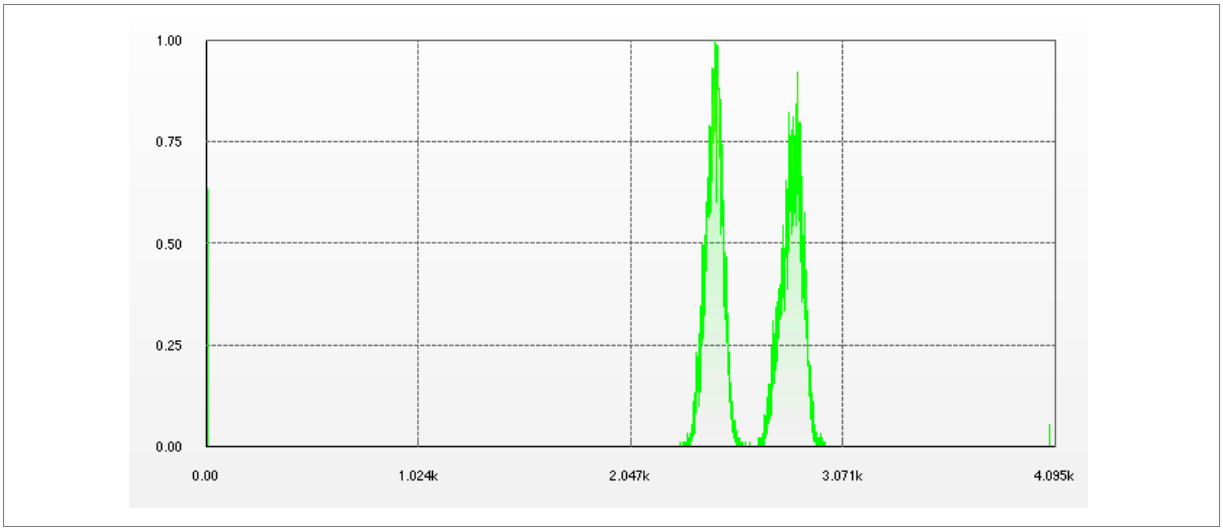
Below is an example of Dragster DR16K3.5 raw image, in bright, without any calibration.

Figure 1: Image captured in light, with default settings and with no calibration applied



The image histogram serves as the guiding reference throughout the entire calibration process. As can be observed, the histogram presents itself with a bimodal distribution, being the values distributed by the odd and even pixels of the sensor.

Figure 2: Histogram from the previous raw image



The goal is to overlay top and bottom pixel values, resulting in a unimodal histogram, as in Figure 8, to achieve as close as possible to a uniform pixel line.

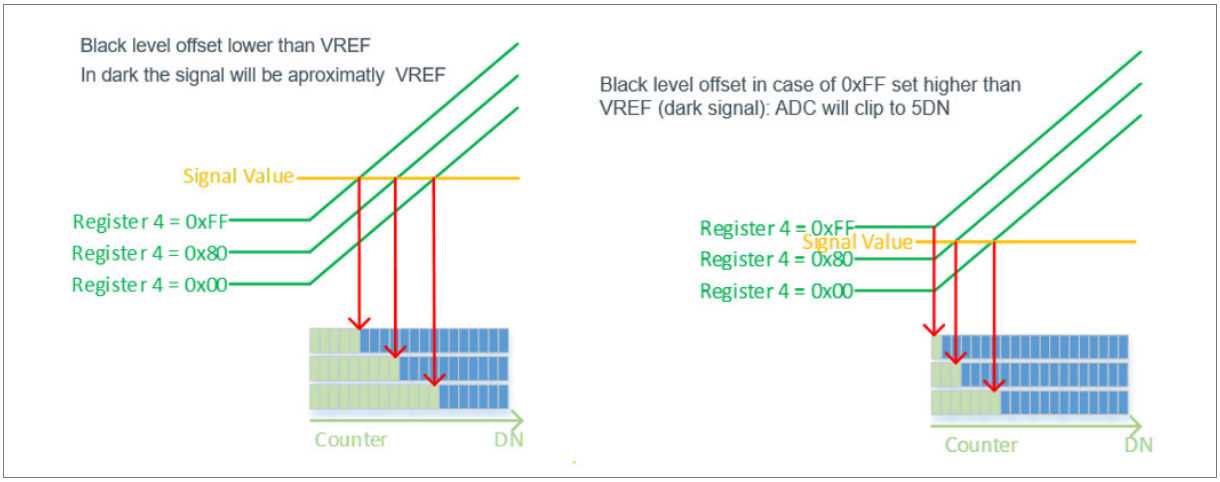
[2] For details regarding the registers, please consult the datasheet - Dragster_DS000444.

2.2.1 Black level calibration

The goal is to place the sensor in dark and adjust the black level value to achieve an output target value ranging from 150 to 200DN (avoiding signal clipping). Register 4 is responsible for defining the black level in the image. For the DR2xXK7 and DRXK3.5 variants, each Register 4, from top and bottom electronics, needs to be adjusted individually.

If register 4 cannot be tuned to the desired value, it is advised to use the bandgap circuit to increase the resolution to the offset register value. In this case, bits 5:3 from register 0x05 can be adjusted to increase the reference current from 100% to 112%. For further details, please refer to the application note Dragster_Calibration_Algorithms_AN001072.

Figure 3: Black level calibration



2.2.2 ADC gain calibration

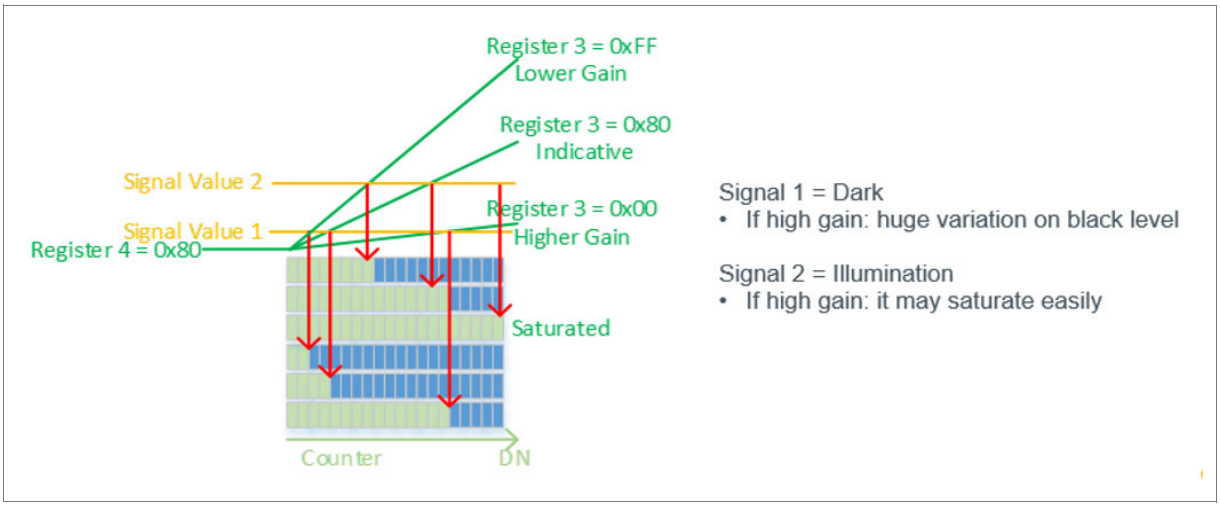
Once the first step of calibration in dark is performed, then the goal is to calibrate the sensor in illumination, to reduce even more the mismatch, due to pixel-to-pixel gain variations.

Considering a fixed integration time, light source intensity and homogeneity, the user needs to adjust the register 3 (ADC gain) of top and bottom electronics to achieve pixel line uniformity in bright conditions. Please note that the higher the register setting value, lower the gain value and vice-versa.

On this application note, the exposure time and the light source intensity are set to achieve a mean signal around 80% of the ADC saturation (~ 3200 DN).

Please keep in mind that adjusting register 3 also affects the signal output value in dark. Therefore, it is recommended, at least, a second iteration of the dark calibration, as in section 2.2.1. This is also mentioned in section 2.2.3.

Figure 4: ADC gain calibration



2.2.3 Interaction between register 3 and 4

The actions performed in register 3 and 4 essentially serve as the calibration required to achieve the optimal configuration.

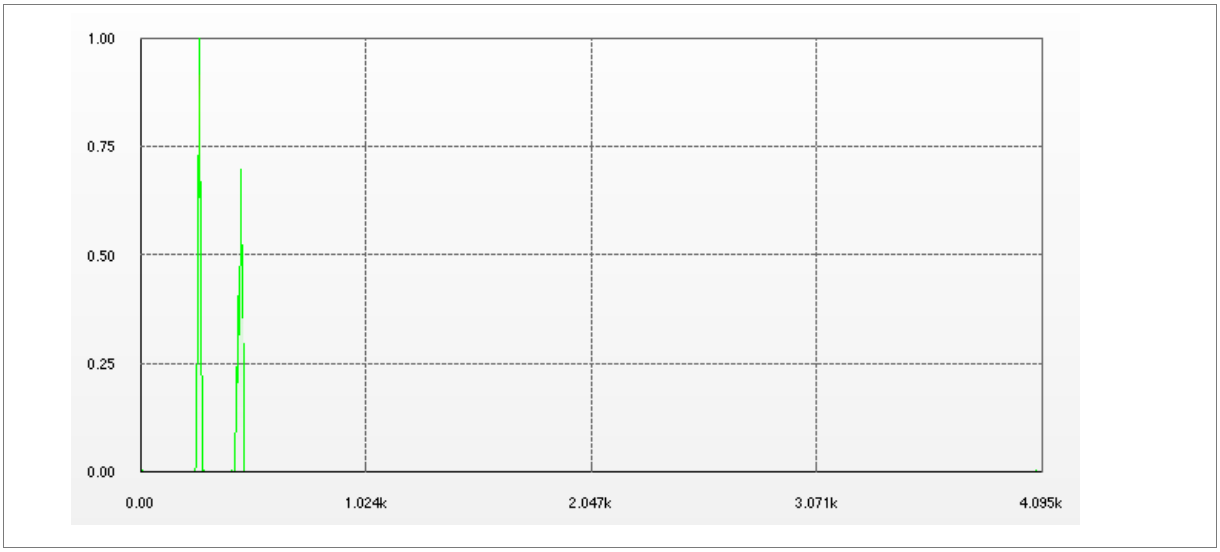
Calibration procedure:

1. Place the device in dark condition, and act on register 4 to achieve an output between 150 to 200 DN (~4% ADC range). Please note that for the DR2xXK7 and DRXK3.5 variants, each Register 4, from top and bottom electronics, needs to be adjusted.
2. If register 4 is not tuned to the desired value, adjust bits 5:3 in register 0x05 to increase the reference current from 100% to 112%, ensuring the sensor's full dynamic range. After making these adjustments, repeat step one.
3. Set the light source illumination intensity and integration time to achieve approximately a mean value of around 80% ADC saturation (~ 3200 DN).
4. Act on register 3 to fine tune and achieve the same output around 3200 DN. Please note that for the DR2xXK7 and DRXK3.5 variants, each Register 3, from top and bottom electronics, needs to be adjusted.
5. Place the device in dark again and check the output value. If necessary, act on register 4 again to maintain the output in between 150 to 200 DN.
6. Set again the light source and integration time to achieve 80% ADC saturation.
7. Check the output and readjust again register 3, if needed, to keep the output ~3200 DN and uniform pixel line value.

Following the process above, the calibration procedure is complete, and the achieved values represent the optimal configuration settings.

Figure 5: Raw image without black level calibration

Figure 6: Histogram from the raw image without black level calibration



The fine-tuning process aims to align the lower histogram to overlap with the other.

Following the black level calibration, the resulting raw image is as exemplified in Figure 7 and respective histogram on Figure 8.

Figure 7: Raw image after black level calibration

Figure 8: Histogram resulting from the black level calibration

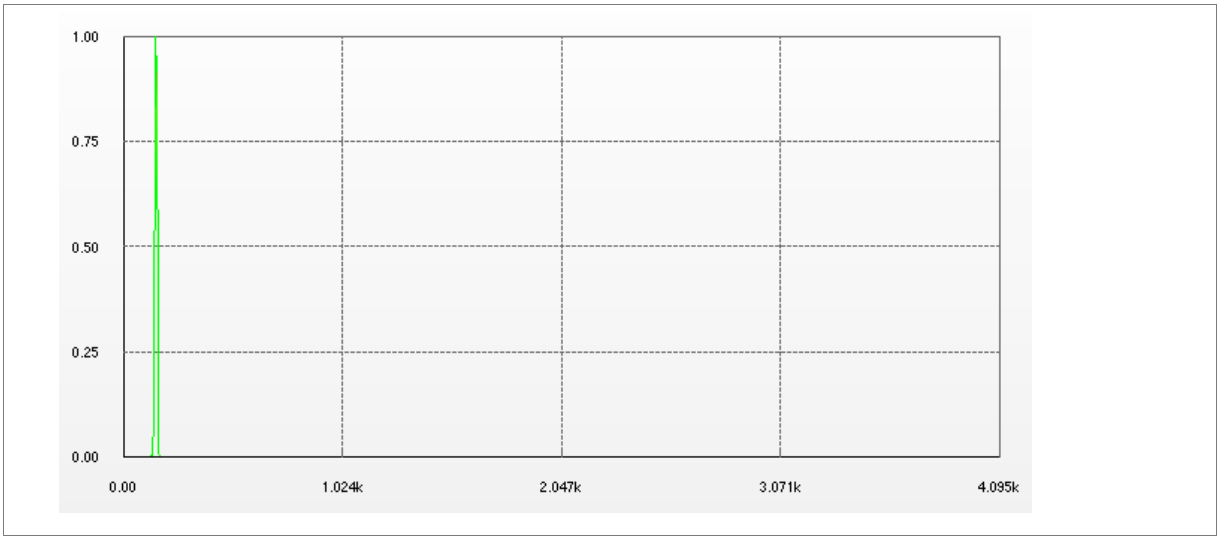


Figure 9 and Figure 10 below, exemplify the non-calibrated image, when in illumination.

Figure 9: Raw image without ADC gain calibration

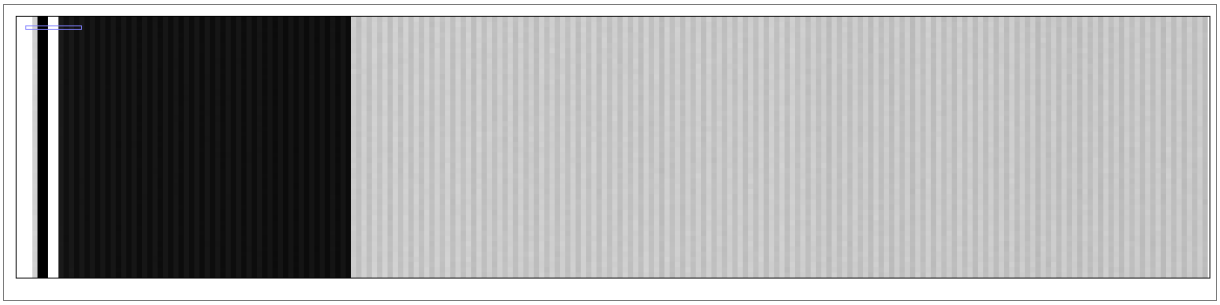
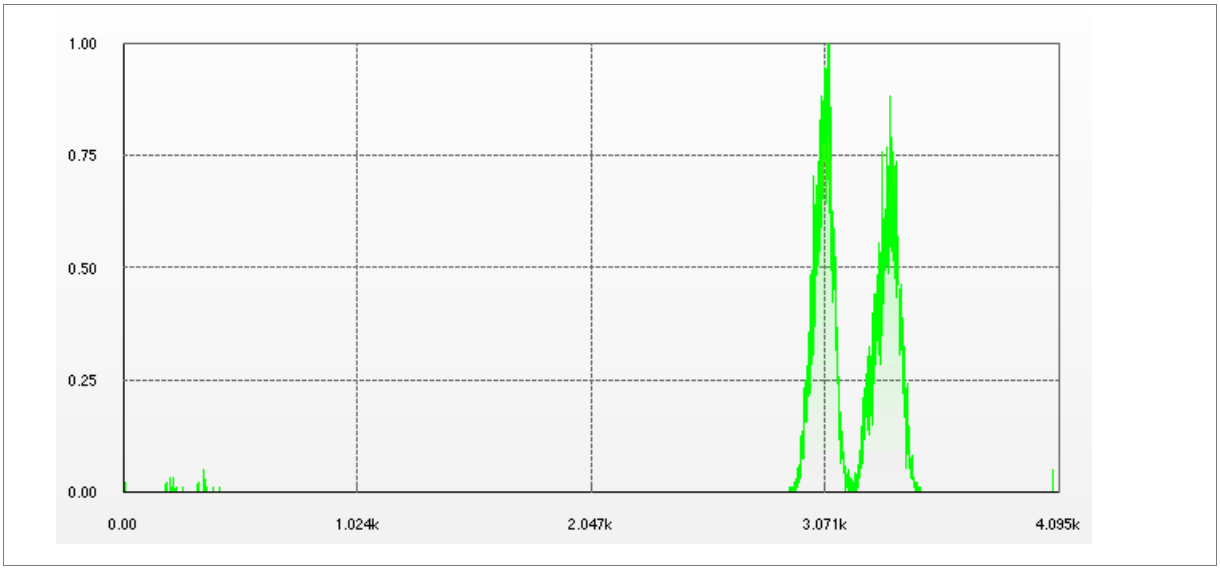


Figure 10: Histogram from the raw image without ADC gain calibration



Upon finishing the calibration process, the sensor displays a uniform response throughout the entire range, as shown in Figure 11 and respective histogram on Figure 12.

Figure 11: Raw image after ADC gain calibration

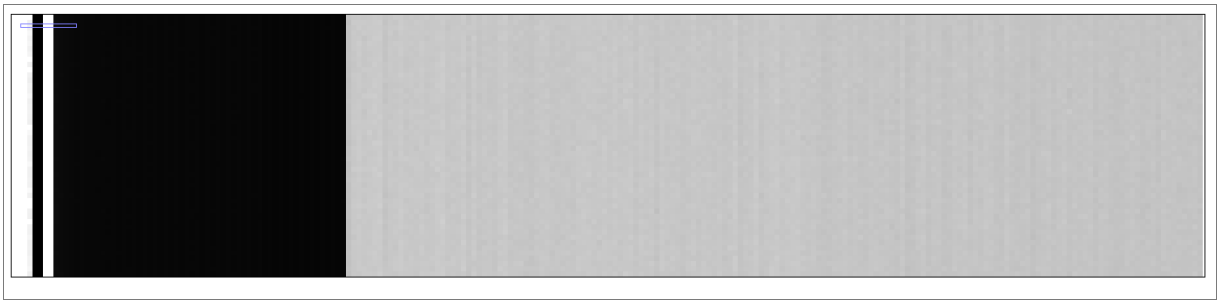
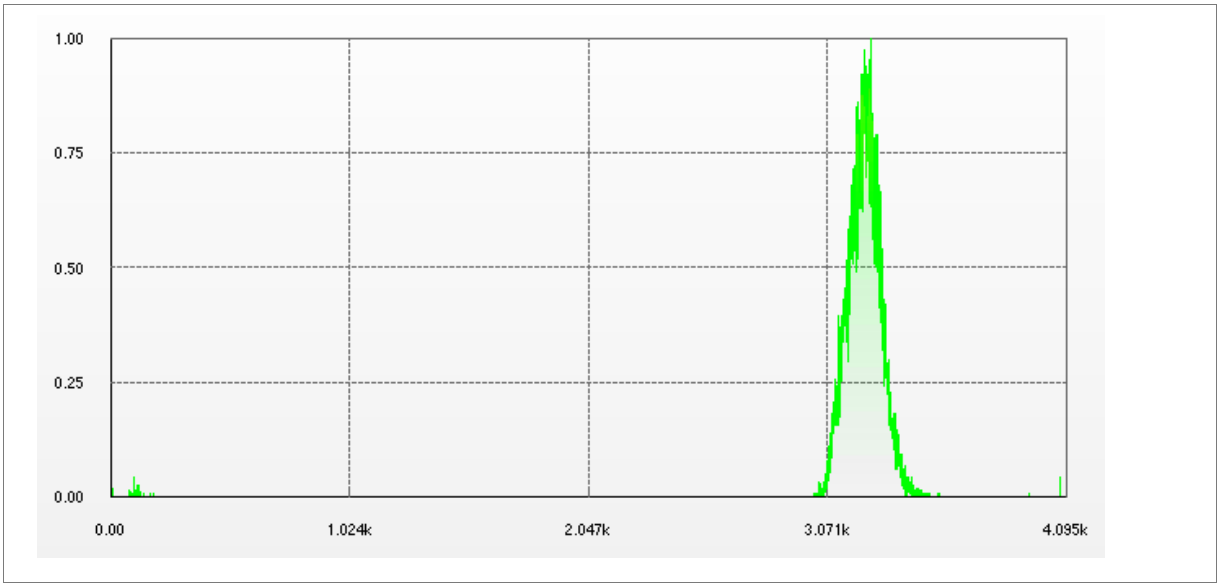


Figure 12: Histogram resulting from the ADC gain calibration

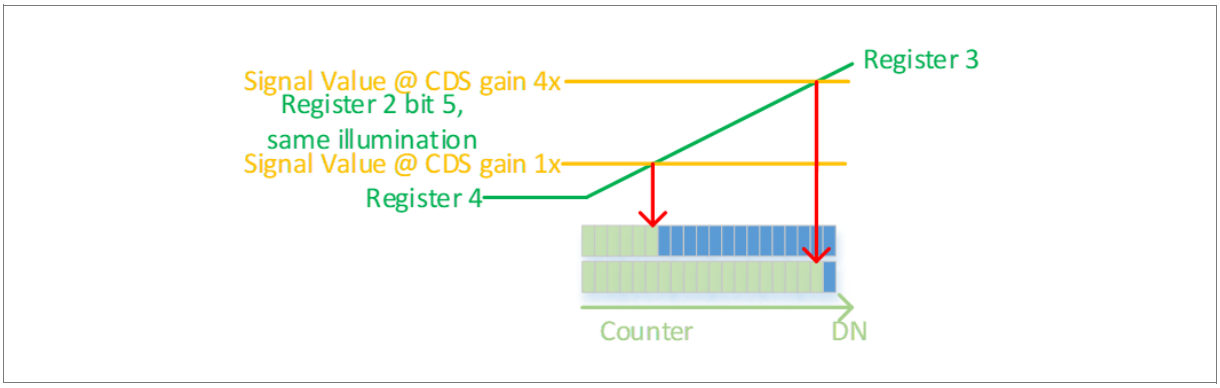


2.2.4 Acting on CDS gain

Adjusting the CDS analogue gain by modifying register 2, bit 5, will result in an amplification of the signal, possibly causing saturation with minimal light signal.

It can be used in low light situations at the expense of noise performance.

Figure 13: Acting on CDS gain



Information:

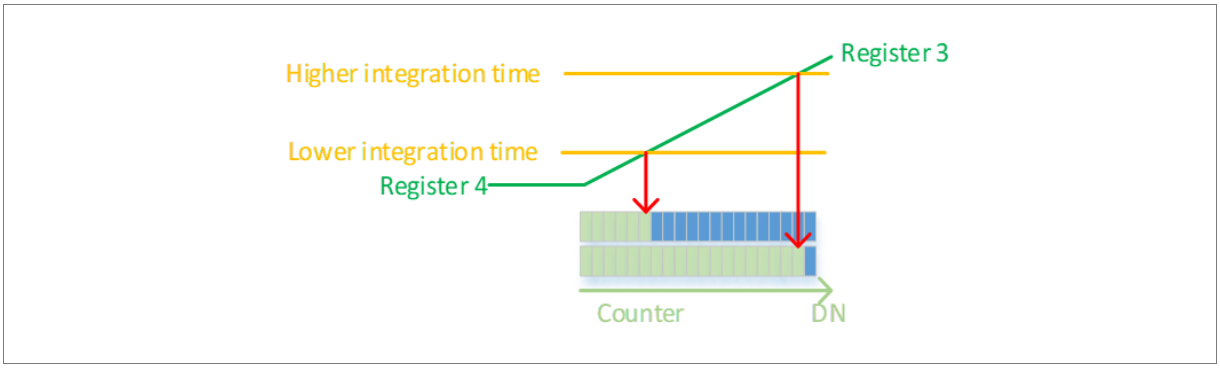
To improve noise performance, act on the exposure time and illumination instead of acting in the CDS gain.

2.2.5 Acting on integration time

Increasing the integration time will increase the signal value, possibly causing saturation at very low illumination intensity.

To change the integration time, it is necessary to modify the time between the falling edge of RST_CDS signal and the falling edge of the SAMPLE signal. Increasing this time difference will result in a longer exposure time.

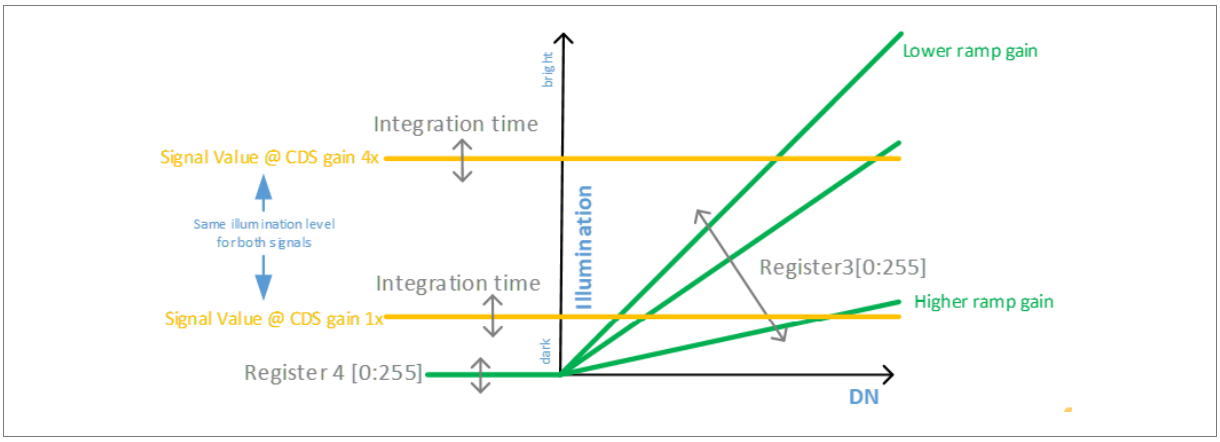
Figure 14: Acting on integration time



2.2.6 Combinations of actions

Figure 15 presents the possible combinations, indicating where adjustments can be made to ensure the device operates at its optimal point while maintaining performance.

Figure 15: Combinations of actions



Information:

Increasing the CDS gain or ADC gain will amplify the noise. If possible, it is advisable to adjust the illumination level, or integration time.

Additionally, pseudocode for adjusting both the Dragster ADC offset and ADC gain is also provided. Please consult the application note Dragster_Calibration_Algorithms_AN001072 for further information.

3 Revision information

Changes to current revision v1-00	Page
Initial production version	

- Page and figure numbers for the previous version may differ from page and figure numbers in the current revision.
- Correction of typographical errors is not explicitly mentioned.

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