Dragster – Calibration algorithms

Application Note

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Valid for:
Applicable to all Dragster versions

Abstract

This application note provides calibration algorithms for Dragster focusing on bandgap switches, as well as ADC offset and gain. The provided algorithms aim to optimize Dragster's performance, enhancing measurement accuracy and consistency between segments. Practical implementation guidelines are included for smoothly integration into Dragster-based systems.

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1 Introduction

The purpose of this application note is to offer pseudocode for fine-tuning Dragster bandgap switches, as well as ADC offset and ADC gain. This adjustment aims to minimize the mismatch between pixel segments values, ensuring a consistent linear light response across all over the pixel line, and, consequently, reducing DSNU and PRNU.

2 Algorithm for bandgap switches adjustment

Due to manufacturing variations, the currents produced by the bandgap circuit can differ between production batches. To prevent a parametric yield loss from this spread, the Dragster chip includes a bias trimming feature, controlled over SPI registers.

In most production batches, the default register settings are sufficient, but some batches may require adjustments, avoiding the pixel clipping in dark and ensuring the maximum dynamic range possible. Below is described a strategy for automatically adjusting the bandgap switches.

2.1 Procedure

1. The default setting for the bandgap switch is at 100% (register 0x5 bit[5:3] = 010).

2. During sensor operation at dark, a reference image is captured by keeping the RST_CVC and RST_CDS signals at constant logic high level. This ensures that all pixels are reset to the

initial VRST level, representing the baseline noise inherent to the sensor.

3. The goal is to understand if, with the current bandgap adjustment and lowest ADC offset level (highest register value setting), the pixels are clipping or not. Please note that Dragster sensor clipping level is at 5 DN (not 0 DN).

4. The mean of the pixel values from the readout reference image is computed, and it shall be named as line_mean for the purpose of this explanation.

```
max_reg_value = 0xFF # Maximum register value

set_offset_register(max_reg_value) //Sets offset register to the maximum value

line_mean = get_sensorMeanDN(max_reg_value) //Gets image average


//Line average comparison to define bandgap current

if line_mean > 5DN

    set register 0x05 bits[5:3] = 100b // Change bandgap current to 112%

else

    set register 0x05 bits[5:3] = 010b // Maintain default bandgap current
                                          at 100%
```

3 Algorithm for ADC offset adjustment

The black level of each sensor can be calibrated by adjusting the offset register (0x04). This ensures that the ADC range aligns with the analog level of the dark reference signal.

It is recommended to set the target black level between 100DN and 200DN for 12-bit operation. However, alternative target black level values may be selected based on the specific application requirements. Therefore, the table below should be considered as an example only.

Table 1: Example values for calibrating the black level

	Target_Low	Target_High
12-bit operation	100DN	200DN

For sensors featuring both top and bottom connectors, the calibration process can start, for instance, by adjusting the bottom taps. Following this, adjustments are made to the top taps to achieve a mean value that closely matches the bottom taps.

3.1 Procedure

1. During sensor operation at dark, a reference image is captured by keeping the RST_CVC and RST_CDS signals at constant logic high level. This ensures that all pixels are reset to the initial VRST level, representing the baseline noise inherent to the sensor.

2. The goal is to perform a binary search with ADC offset register, to quickly achieve the value for the target DN value in dark.

3. The mean of the pixel values from the readout reference image is computed, and it shall be named as line_mean for the purpose of this explanation.

```
//Initialize parameters
target_value = 150d       // Target DN value in 12-bit
start = 0                 // Example of minimum offset register value
stop = 255d               // Example of maximum offset register value
margin = 1                // Margin for the binary search end condition

//Begin binary search loop
while (stop - start) > margin
       currentRegValue = floor ((start + stop)/2) //Calculates center value
       set_offset_register(currentRegValue) //Sets offset register to the
                                              center value
       line_mean = get_sensorMeanDN(currentRegValue) //Gets image average

       if (line_mean < mean_target)
              stop = currentRegValue //Updates the search to the lower range
       else
              start = currentRegValue //Updates the search to the upper range

       //Gets the mean of each register value
       line_mean_start = get_sensorMeanDN(start)
       line_mean_stop = get_sensorMeanDN(stop)

       //Selects the register value closer to the target value
```

```
if abs(line_mean_start - target_value) < abs(line_mean_stop -
                                              target_value)

     best_register_value = start

else

     best_register_value = stop
```

4 Algorithm for ADC gain adjustment

Once the black level is within the desired range, the ADC gain, register 0x03, needs to be fine-tuned.

It is recommended to set the mean signal to around 80% of the ADC saturation value. For 12-bit operation, this corresponds to a range of 3000DN and 3400DN. However, alternative target values may be selected based on the specific application requirements. Therefore, the table below should be considered as an example only.

Table 2: Example values for adjusting the ADC gain

	Target_Low	Target_High
12-bit operation	3000DN	3400DN

For sensors featuring both top and bottom connectors, the calibration process can start, for instance, by adjusting the bottom taps. Following this, adjustments are made to the top taps to achieve a mean value that closely matches the bottom taps.

4.1 Procedure

1. The goal is to perform a binary search with ADC gain register, to quickly achieve the value for the target DN value in bright.
2. The mean of the pixel values from the readout is computed, and it shall be named as line_mean for the purpose of this explanation.

```
//Initialize parameters

target_value = 3200d          // Target DN value in 12-bit

start =16d                    // Example of minimum gain register value

stop = 32d                    // Example of maximum gain register value
```

```
margin = 1                    // Margin for the binary search end condition

//Begin binary search loop
while (stop - start) > margin:
       currentRegValue = floor ((start + stop)/2) //Calculates center value
       set_offset_register(currentRegValue) //Sets gain register to the
                                                  center value
       line_mean = get_sensorMeanDN(currentRegValue) //Gets image average

       if (line_mean < mean_target)
              stop = currentRegValue //Updates the search to the lower range
       else
              start = currentRegValue //Updates the search to the upper range

       //Gets the mean of each register value
       line_mean_start = get_sensorMeanDN(start)
       line_mean_stop = get_sensorMeanDN(stop)

       //Selects the register value closer to the target value
       if abs(line_mean_start - target_value) < abs(line_mean_stop -
                                                      target_value)
              best_register_value = start
       else
              best_register_value = stop
```

Information:

Please note that there is a maximum setting for the ADC end of range register (0x09). It is recommended to not exceed the following value:

- ADC End of Range = 4096DN (12bit) -> Register 0x09 = 0x80

5 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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