Product Document

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Application Note

AN001056

Fine Analog Gains

Mira050

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Content Guide

1 Introduction

Mira050 is a high-speed CMOS global shutter sensor for NIR consumer applications.

By default, Mira050 implements a few discrete steps of analog gain (1x, 2x, 4x up to 16x depending on the bit mode). In addition, also digital gain is available in fine steps of a 1/16th increment.

1.1 What to Expect

This application note will explain how to implement fine analog gain steps using Mira050 as well as the limitations.

The fine analog gains are available in the following modes:

- 8-bit (up to 16x, with 3% increments).
- 10-bit_highspeed (up to 4x, with 3% increments).

Advantages:

- Fine gain control, useful for AEC algorithms.
- Slight noise improvement, especially in 8-bit mode.

Disadvantages:

- Lower framerate (same as native 8-bit gain x16 or 10-bit_highspeed gain 4x) compared to the native 1x gain.
- Slightly higher power consumption (same as above).
- Takes some work to implement.

1.2 How it Works

Every combination of gain and bit mode has been fully optimized for fps, noise and power.
Usually, the higher the gain, the lower the framerate. This has to do with the way the ADC works.

For the fine analog gains, we configure the sensor at the slowest possible timing (which matches the higher gain) and then tune down only the analog gain.

In practice, this means starting from the settings of 8-bit gain x16 or 10-bit_highspeed gain x4.

Then, there is an accompanying CSV lookup table with register settings matching each gain setting.

It is explained in detail in the next chapter.

2 Implementing Fine Analog Gains

2.1 Instructions

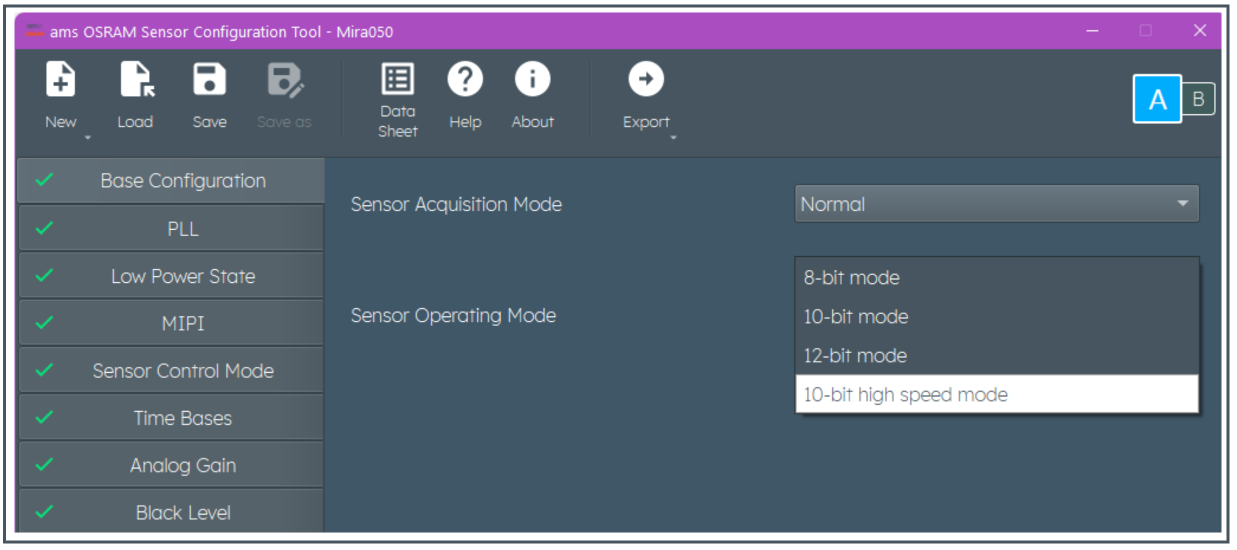
2.1.1 Step 1: Base Upload

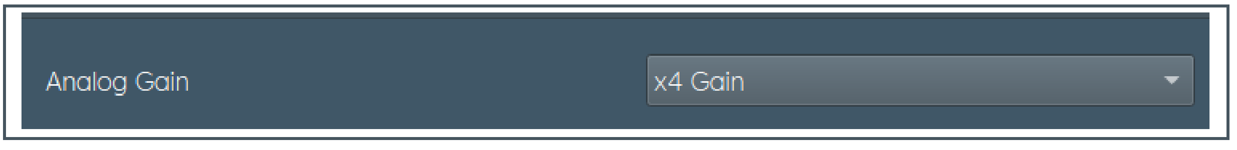
> Start with register sequence for 8-bit gain x16 or 10-bit high speed gain x4.

This sequence can be generated using the ams OSRAM Sensor Configuration Tool, or can be found in the user guide.

1. Click on base configuration, select 8-bit or 10-bit high speed.
2. Click on analog gain tab, select **16x (for 8-bit)** or **4x (for 10-bit high speed)**
3. Click export -> address based txt

Figure 1:
Configuration Tool





2.1.2 Step 2: Adjusting Fine Gains Using the CSV File.

Upload desired gain according to the lookup table (see separate csv file or at the end of this document.).

Figure 2:
Register Uploads

Register	Address	Width	Value
BANK_SEL	0xE000	[7:0]	1
GDIG_AMP (digital gain)	0x0024	[7:0]	Digital_gain*16-1 (see CSV)
BANK_SEL	0xE000	[7:0]	0
BIAS_RG_ADCGAIN (adc gain)	0x01F0	[5:0]	Rg_adcgain (see CSV)
BIAS_RG_MULT	0x01F3	[1:0]	Rg_mult (see CSV)
OFFSET_CLIPPING	0x0193	[14:0]	OFFSET_CLIPPING (formula below)

Equation 1:
Target black level calculation (OFFSET_CLIPPING)

$$OFFSET_{CLIPPING} = ADC_{OFFSET} + ROUND\left(\frac{\frac{OTP\_offset - 2250}{scale\_factor} - target\_interpolated}{digital\_gain}\right)$$

Scale_factor = 4

Adc_offset = 1702

Target_interpolated = target + (otp_high/400 - otp_low/400)/(4-1) *(16 - analog_gain)

Target = desired black level in DN, example: 64

Otp_offset (FROM OTP 0x1)

Otp_high (FROM OTP 0x2)

Otp_low (FROM OTP 0x3)

Analog_gain = desired fine gain setting (e.g 3.62)

Digital gain (1, 0.5, 0.25 from csv LUT)

Figure 3:
OTP Table

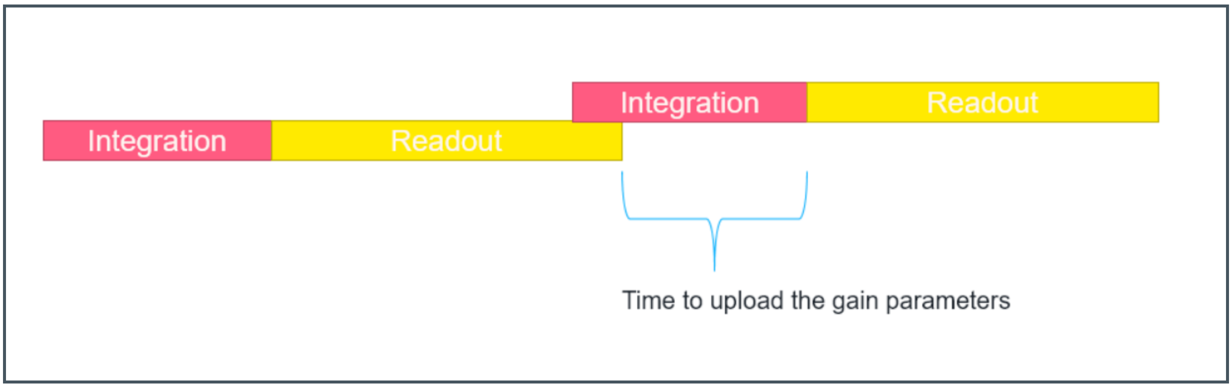
Addr	Bit	Type	Description
0x01	15:0	UINT16	Mean of dark in 12-bit mode, gain 4x for calibration
0x02	15:0	UINT16	mean of dark*100 in 10bithighspeed gain4 with finegain=4
0x03	15:0	UINT16	mean of dark*100 in 10bithighspeed gain4 with finegain=1
0x1B	15:0	UINT16	Calibration data 60C
0x1D	31:16	UINT16	Internal ID info
0x1D	15:8	UINT8	Internal ID info
0x1D	7:0	UINT8	Internal ID info
0x1E	23:16	UINT8	Internal ID info
0x1E	15:8	UINT8	Internal ID info
0x1E	7:0	UINT8	Internal ID info
0x25	7:0	UINT8	Internal ID info

3 Timing Constraints

Mira050 fine gain can be uploaded outside of the readout time.

If parameters are updated during the readout, immediate gain changes will be applied and disrupt the image.

Figure 4:
Timing of Uploads



4 On the Evaluation Kit

Make sure to update the kit to the latest version (contact your FAE).

Currently, the fine analog gains are only available in 8-bit mode and 10-bit_highspeed mode.

We have command line tools available to read out the images in 8-bit and 10-bit.

Figure 5:
Command Line Tools for Fine Gains

```
jetcis@jetcis-desktop:~/ams_jetcis-3.1.0.post1.dev43+g92b0828$ source venv/bin/activate
(venv) jetcis@jetcis-desktop:~/ams_jetcis-3.1.0.post1.dev43+g92b0828$ cd scripts/ && ls
capture_raw.py  live_view_isp.py  live_view_raw.py  mira050  Mira220
(venv) jetcis@jetcis-desktop:~/ams_jetcis-3.1.0.post1.dev43+g92b0828/scripts$ python capture_raw.py -se mira050 -ag 4.7 -b '8bit' -e 500
3.1.0.post1.dev43+g92b0828
Running 'capture_raw.py'
starting capture script w parameters 500 20 1 0 8bit 4.7 1
```

> To capture and save images, use the *capture_raw.py* script with as bit mode argument: **'8bit' or '10bithighspeed'**

Similarly, for a live view, use the *live_view_raw.py* script.

To capture images with all analog gains at once, there is a script called test_fine_gains.py which will sweep over all available gains and save raw images in that mode (inside the scripts/mira050 folder).

The python script can be adjusted to the user's needs.

Figure 6:
Run Script

```
(venv) jetcis@jetcis-desktop:~/jetcis_software_internal/jetcis_software/scripts/mira050$ python test_fine_gains.py
```

4.1 Reverting to the Old Settings:

Set fine_gains to false in this config file:

Figure 7:
Edit Configuration

```
(venv) jetcis@jetcis-desktop:~/ams_jetcis-3.1.0.post1.dev49+g005958d$ cat sensor_configuration.toml
# This is a file that can be edited by the user for sensor and evk tweaks.

title = "sensor_config"

[mira050]
fine_gains = true


(venv) jetcis@jetcis-desktop:~/ams_jetcis-3.1.0.post1.dev49+g005958d$
```

5 Appendix: Lookup Tables

5.1 Settings for 8-bit Gain x16

Figure 8:
Setting Table for 8-bit Gain 16

analog_gain	dig_gain	rg_adcgain	rg_mult
1	0.25	36	3
1.018	0.25	35	3
1.056	0.25	33	3
1.075	0.25	32	3
1.118	0.25	30	3
1.14	0.25	29	3
1.188	0.25	27	3
1.213	0.25	26	3
1.267	0.25	24	3
1.295	0.25	23	3
1.326	0.25	22	3
1.373	0.25	62	2
1.425	0.25	59	2
1.462	0.25	57	2
1.5	0.25	55	2
1.541	0.25	53	2
1.583	0.25	51	2
1.652	0.25	48	2
1.701	0.25	46	2
1.727	0.25	45	2
1.781	0.25	43	2
1.839	0.25	41	2
1.9	0.25	39	2
1.966	0.25	37	2
2	0.25	36	2
2.073	0.25	34	2
2.151	0.25	32	2

analog_gain	dig_gain	rg_adcgain	rg_mult
2.192	0.25	31	2
2.28	0.25	29	2
2.327	0.25	28	2
2.426	0.25	26	2
2.478	0.25	25	2
2.533	0.25	24	2
2.651	0.25	22	2
2.714	0.25	63	1
2.78	0.25	61	1
2.886	0.25	58	1
2.961	0.25	56	1
3.04	0.25	54	1
3.167	0.25	51	1
3.257	0.25	49	1
3.353	0.25	47	1
3.455	0.25	45	1
3.563	0.25	43	1
3.619	0.25	42	1
3.738	0.25	40	1
3.864	0.25	38	1
4	0.25	36	1
4.071	0.5	35	2
4.222	0.5	33	2
4.302	0.5	32	2
4.471	0.5	30	2
4.56	0.5	29	2
4.75	0.5	27	2
4.851	0.5	26	2
5.067	0.5	24	2
5.182	0.5	23	2
5.302	0.5	22	2
5.494	0.5	62	1
5.7	0.5	59	1
5.846	0.5	57	1
6	0.5	55	1

analog_gain	dig_gain	rg_adcgain	rg_mult
6.247	0.5	52	1
6.423	0.5	50	1
6.609	0.5	48	1
6.806	0.5	46	1
7.015	0.5	44	1
7.238	0.5	42	1
7.355	0.5	41	1
7.6	0.5	39	1
7.862	0.5	37	1
8.143	1	35	2
8.291	1	34	2
8.604	1	32	2
8.769	1	31	2
9.12	1	29	2
9.306	1	28	2
9.702	1	26	2
9.913	1	25	2
10.133	1	24	2
10.605	1	22	2
10.857	1	63	1
11.259	1	60	1
11.544	1	58	1
11.844	1	56	1
12.324	1	53	1
12.667	1	51	1
13.029	1	49	1
13.412	1	47	1
13.818	1	45	1
14.25	1	43	1
14.71	1	41	1
14.951	1	40	1
15.458	1	38	1
16	1	36	1

5.2 Settings for 10-bit Gain x4

Figure 9:
Setting Table for 10-bit Gain 4

Gain	gdig_amp	rg_adcgain	rg_mult
1	1	36	3
1.018	1	35	3
1.056	1	33	3
1.075	1	32	3
1.118	1	30	3
1.14	1	29	3
1.188	1	27	3
1.213	1	26	3
1.267	1	24	3
1.295	1	23	3
1.326	1	22	3
1.373	1	62	2
1.425	1	59	2
1.462	1	57	2
1.5	1	55	2
1.541	1	53	2
1.583	1	51	2
1.652	1	48	2
1.701	1	46	2
1.727	1	45	2
1.781	1	43	2
1.839	1	41	2
1.9	1	39	2
1.966	1	37	2
2	1	36	2
2.073	1	34	2
2.151	1	32	2
2.192	1	31	2
2.28	1	29	2
2.327	1	28	2
2.426	1	26	2

Gain	gdig_amp	rg_adcgain	rg_mult
2.478	1	25	2
2.533	1	24	2
2.651	1	22	2
2.714	1	63	1
2.78	1	61	1
2.886	1	58	1
2.961	1	56	1
3.04	1	54	1
3.167	1	51	1
3.257	1	49	1
3.353	1	47	1
3.455	1	45	1
3.563	1	43	1
3.619	1	42	1
3.738	1	40	1
3.864	1	38	1
4	1	36	1

6 Revision Information

Changes from previous version to current revision v2-00	Page
Updated OTP table	6

- 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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