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Application Note

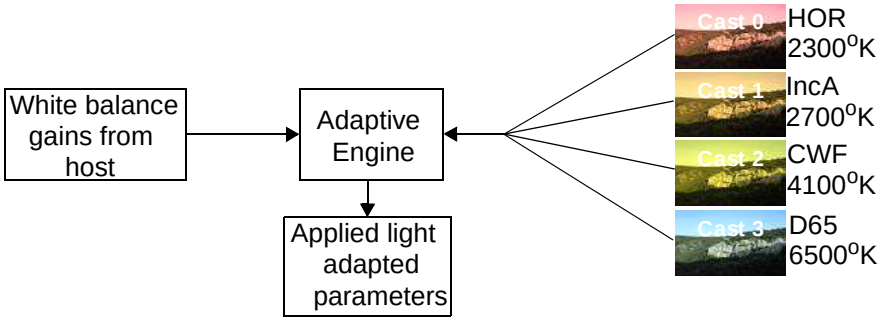
VD6953 Lens Shading Correction Guide

Introduction

This apps note is intended to help the user calculate the parameters required for lens shading correction for the VD6953. It will attempt to cover both laboratory and production methods.

The VD6953 can utilise an advance on-chip lens shading correction algorithm, known as the 'AV2x2' block. In addition there is a green imbalance corrector before the EDOF block which helps the EDOF performance. This corrector is known as the 'gimbal' block.

The VD6953 uses an adaptive algorithm driven by white balance gains from the host. There are 4 sets of parameters held for both gimbal and av2x2, one set per colour temperature. As the scene changes the adaptive algorithm interpolates between the 2 nearest sets of data. An index is required for each colour temperature, this is the normalised red gain (r-norm) based on the white balance gains from the host.



1 Laboratory based method

1.1 Image Capture

Completely flat images should be captured under four different colour temperatures. One easy method of doing this is to place a diffuser directly over the lens in a light box. There are a few requirements for the image capture:

- Pedestal **MUST** be zero
- Images should be 10-bit .pgm file
- Analogue gain should be set at 1.0
- Maximum pixel level should not be greater than 80% (i.e. approx 800 codes in the green channel at the centre of image)
- All on-chip correction (i.e. Gimbal and AV2x2) **MUST** be disabled

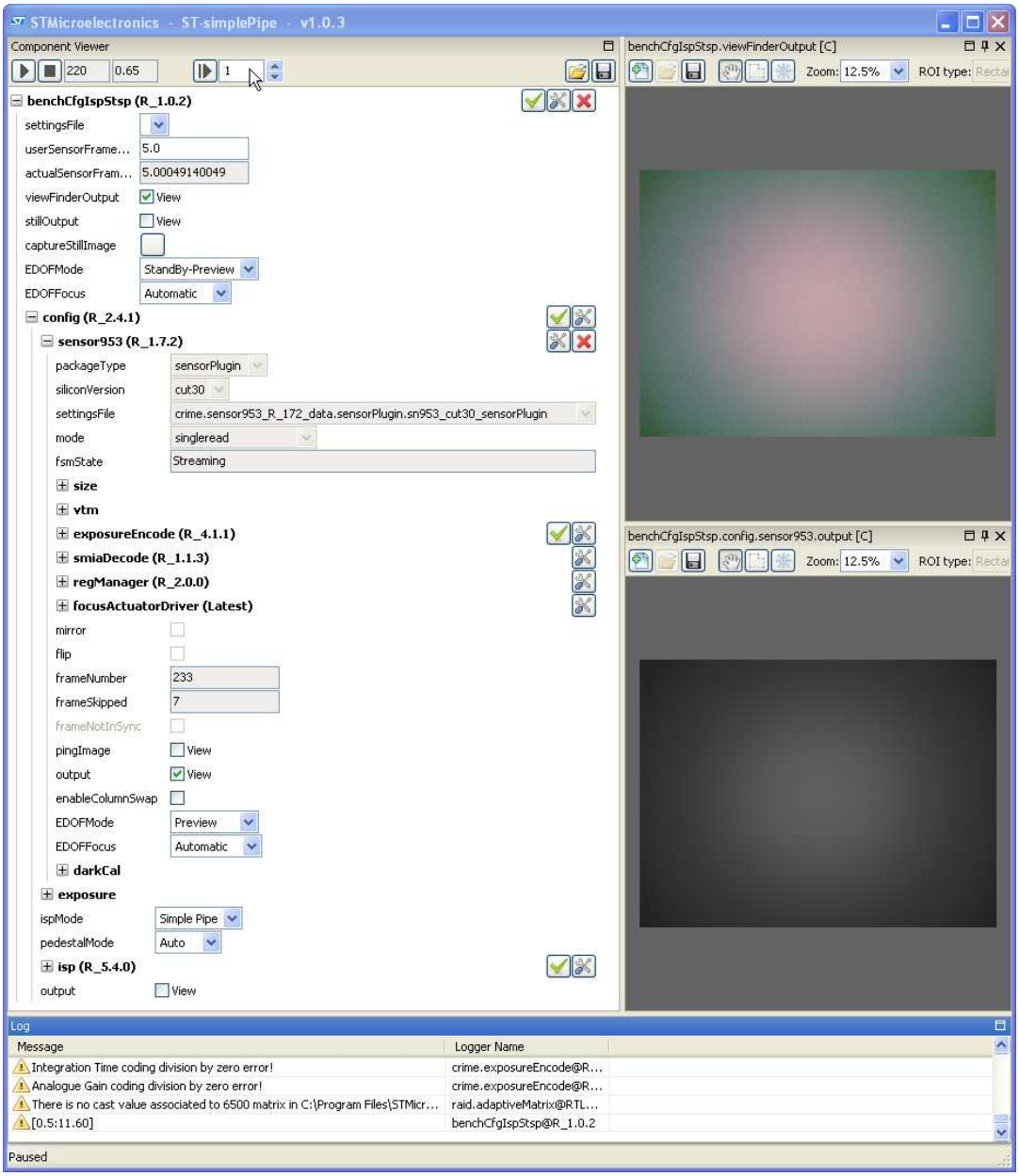
Table 1. Registers relevant to image capture

Register Address	Register Name	Register Settings	Comments
0x0b00	shading_correction_enable	0x00: Disable 0x01: Enable	Set to 0x00 to turn off the AV2x2 correction block
0x0205	analogue_gain_code	Range: 0x00 to 0xf0	Set to 0x00 to make analogue gain = 1
0x31e8	clip1_enable	0x00: Disable 0x01: Enable	Set to 0x00 to ensure that output data has a pedestal of 0
0xfaa3	mapped_gimbal_enable	0x00: Disable 0x01: Enable	Set to 0x00 to turn off the gimbal correction block

One of the easier ways to capture the images is to use ST's 'Druid' software. At the time of writing the current version is 'STsp_Full 1.0.3'. The software should be run in default mode with the following changes (must be stopped before changes are applied):

- Load '953_Sensor_Plug-in.xml' configuration
- Full resolution (singleread mode)
- Use V2WREG to set the registers as detailed in *Table 1* (except analogue gain)
- Use the exposure controls to set the max user analogue gain to 1.0
- Capture images from output of 'sensor953' block - this will be a 10 bit raw bayer .pgm file

Shown here is a screen capture of the Druid software. It is the lower right image that should be saved.



The Druid software allows the generation of gimbal and av2x2 parameters based on the saved images (using the avGen module). There is a separate step by step guide showing this process available on the 953 apps support pages. The advantage of this method is that there is also a facility to convert the dat files to v2wreg scripts (dat2wreg module).

Another method is to use the AVPG (anti-vignette parameter generation) .dll wrapped in a command line based executable. This program is called ‘av_param_gen.exe’. The AVPG folder should be copied anywhere on the PC (in the following example it was copied to the root C drive, ‘C:\AVPG\’).

The simplest way to use the command line executable is to write a batch (.bat) file to automate the generation of parameters. In this example the .bat file was placed in the same folder as the captured images so there was no need for a path before the image name.

The program is called twice per image. The first time it generates and applies the gimbal parameters (mode 3), the second pass uses this intermediate image and generates the av2x2 parameters (mode 4).

1.1.1 Example Script

```
rem generates gimbal and av2x2 parameters for 953 from diffuse images (.pgm)
rem images must have a pedestal of 0

rem gimbal - generates intermediate files that have been gimbal corrected
C:\avpg\av_param_gen -mode 4 -improc 953_d65.pgm 953_d65_gimbal.pgm > d65_gimbal.dat
C:\avpg\av_param_gen -mode 4 -improc 953_cwf.pgm 953_cwf_gimbal.pgm > cwf_gimbal.dat
C:\avpg\av_param_gen -mode 4 -improc 953_incA.pgm 953_incA_gimbal.pgm > incA_gimbal.dat
C:\avpg\av_param_gen -mode 4 -improc 953_hor.pgm 953_hor_gimbal.pgm > hor_gimbal.dat

rem av2x2 - uses the intermediate gimbal files to generate av2x2 params
C:\avpg\av_param_gen -mode 3 -bowl 0.95 953_d65_gimbal.pgm > d65_av2x2.dat
C:\avpg\av_param_gen -mode 3 -bowl 0.95 953_cwf_gimbal.pgm > cwf_av2x2.dat
C:\avpg\av_param_gen -mode 3 -bowl 0.95 953_incA_gimbal.pgm > incA_av2x2.dat
C:\avpg\av_param_gen -mode 3 -bowl 0.95 953_hor_gimbal.pgm > hor_av2x2.dat

rem delete the intermediate images
del 953_d65_gimbal.pgm
del 953_cwf_gimbal.pgm
del 953_incA_gimbal.pgm
del 953_hor_gimbal.pgm

pause
```

In this example of bowl % of 95% (0.95) was used. From experience this normally gives good results, but anywhere between 75% and 100% may give the desired results. The bowl percentage is the target for the corner brightness compared to the centre.

1.1.2 Output Format

The output from the script is two text files per colour temperature, one for gimbal parameters and one for av2x2.

Gimbal:

```
AvGenRaw shared library v1-02
MODE IS 4, ISP is 6, JOBSIZE is 7
R2s 8 PARA 0
JOBSIZE 7 (GR_HOT 1)
GR:  0  0  8  5  0 -4  4
RR:  0  0  0  0  0  0  0
BB:  0  0  0  0  0  0  0
GB:  0  0  0  0  0  0  0
MSE: [GR  1.54] [RR  0.00] [BB  0.00] [GB  0.00]
```

The Gimbal parameter order is:

Unity x x2 x3 y y2 y3

AV2x2:

AvGenRaw shared library v1-02
MODE IS 3, ISP is 6, JOBSIZE is 9
R2s 8 PARA 0
JOBSIZE 9 (GR_HOT 1)
GR: 1-38120-54 43-12158 -8-170
RR: 0-32216-82 -4 32287-42-412
BB: 0 17100-39-42-66137-63-115
GB: 0-36119-53 48-12158-31-171
MSE: [GR 6.64] [RR 11.61] [BB 6.86] [GB 6.58]

The AV2x2 parameter order is:

Unity x x2 y xy yx2 y2 y2x y2x2

These parameters are then ready to be either loaded temporarily into the device using I2C writes or can be programmed into NVM at the relevant locations.

1.1.3 GR/GB select registers

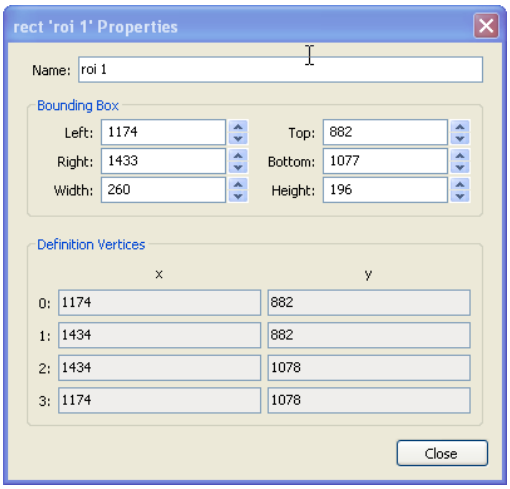
Gimbal operates only on one of the green colour planes; either GR or GB. If the output data is in the GR channel, then the GIMBAL_CHANSEL register {0x3411} must be set to 0x00, if the data is on the GB channel, it must be set to 0x03.

The AV2x2 unity offset likewise only operates on either the GR or GB colour plane. The output data will only have a unity offset on one of the channels, if it is on the GR channel, then the AV2x2_UNITY_GSEL register {0x318b} must be set to 0x00, if the data is on the GB channel, it must be set to 0x01.

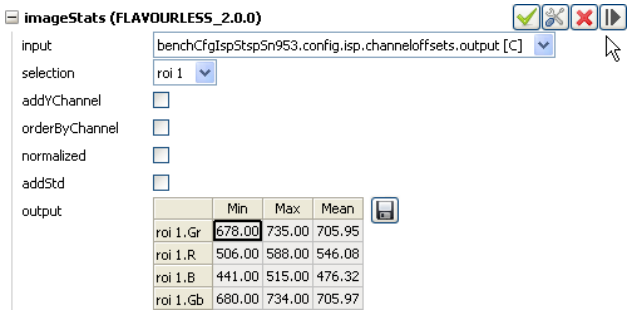
1.1.4 Calculation of colour cast indices

Each set of parameters needs to be associated with a normalised red gain. Again these indices must be programmed into NVM at the appropriate location. These can be calculated as the same time as the images are captured. Within Druid there is an ‘imageStats’ metric that can be used to calculate the normalised red gain (although the avGen tool does this automatically).

When the images are captured, there is no lens shading correction applied. It is therefore important to only use stats from the central 1% area. An ROI of 260 x 196 should be created with the top left hand corner at (1174, 882):



The output from the imageStats metric should look like this:



To calculate the normalised red gain, first the channel gains must be calculated. This should be done in the same way as the host processor will calculate them as it is the host that feeds the channel gains back to the 953.

If we assume a simple grey world white balance, then the channel gains would be calculated as follows:

$$GrGain = \frac{Max(Gr,\ R,\ B,\ Gb)}{Gr}$$

$$RGain = \frac{Max(Gr,\ R,\ B,\ Gb)}{R}$$

$$BGain = \frac{Max(Gr,\ R,\ B,\ Gb)}{B}$$

$$GbGain = \frac{Max(Gr,\ R,\ B,\ Gb)}{Gb}$$

The normalised red gain would then be calculated thus:

$$rnorm = \frac{RGain}{RGain + GGainav + BGain}$$

Where GGainav is the average of the two green channel gains.

So in the example above r-norm = 0.342 (image captured in office lighting).

This number must be multiplied by 256 before being programmed into NVM.

Typical values for the 4 colour casts will typically be approx:

- Cast 3 (D65) 0.44
- Cast 2 (CWF) 0.35
- Cast 1 (IncA) 0.26
- Cast 0 (HOR) 0.22

The exact values will be determined by the light source used and the optical properties of the lens and IR glass.

2 Notes for Production

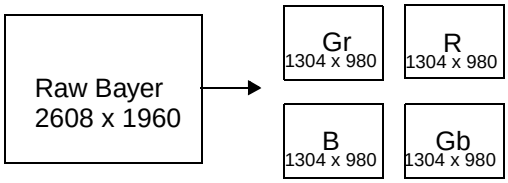
During FMT (final module test), the techniques required for lens shading parameter generation will need to be modified depending on the production environment used.

The same .dll file is used, but it will need to be included in the production test environment. The main difference is that during production it may not be possible in terms of time or equipment to capture images under 4 different colour temperatures. Assuming only 1 colour temp is used, the other 3 sets of parameters can be calculated based on data collected from several modules which have been measured under 4 colour temp.

The capture of images must obey the same rules as the lab method, but because Druid will not be used, the exposure will have to be set by the production test software.

To avoid having to remove the pedestal of 64 in software, it is possible to set register 0x31e8 to 0x0. This will ensure that the output data has 0 pedestal.

For calculation of the colour cast indices, it may be easier to split the image into 4, one per colour plane. Then a centre region of 130 x 98 (1% area) can be measured in each image to obtain the average pixel value. From this the r-norm (colour cast indices) values can be calculated.



The white balance method used should be the same as the host processor will use as it is the host that will write the channel gains to the sensor during normal operation. It may be acceptable to use a simple grey world white balance as outlined in *Section 1.1.4*.

3 Revision history

Table 2. Document revision history

Date	Revision	Changes
04-June-2010	0.1	Initial release.
10-June-2010	0.2	Minor changes & added normalised red gain calculation section.
07-Jul-2010	0.3	Added GR/GB gimbal & AV2x2 select.
17-Jul-2010	0.4	Corrected colour index calculation.
30-Jul-2010	0.5	Updated Druid section.
08-Aug-2010	0.6	Corrected colour cast index order.

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