Hi3516A/Hi3516D IPC Picture Quality Optimization

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Contents

Picture Quality Optimization

As shown in the right diagram, the picture quality can be optimized by adjusting the color, definition and noise as well as others in sequence.

Preparations

- Connect and adjust the sensor to output images.
- Select the optical filter.
- Manually configure the exposure time and gain of the sensor.
  - You can use the HiSilicon PQ Tools.
- Capture Raw images output from the sensor.
  - Run the vi_bayerdump program in **mpp/tools** of the SDK or use the ITTP_Stream component of the HiSilicon PQ Tools.
- Correctly configure video processing subsystem (VPSS) attributes.
  - Run the vpss_attr program in **mpp/tools** of the SDK by following the *HiMPP V2.0 Media Processing Software Development Reference*. Ensure that the 3DNR has been enabled.

Correction Software

- ISP Calibration Tool V1.1.3
- HiSilicon PQ Tools
- ImageJ V1.47 (available on the ImageJ website)
- HYRes
- Imatest

Correction Devices

- (Optional) Color temperature illuminometer
- Illuminant light box with various color temperatures

  At least the D75, D50, TL84, and A illuminants are used during correction.

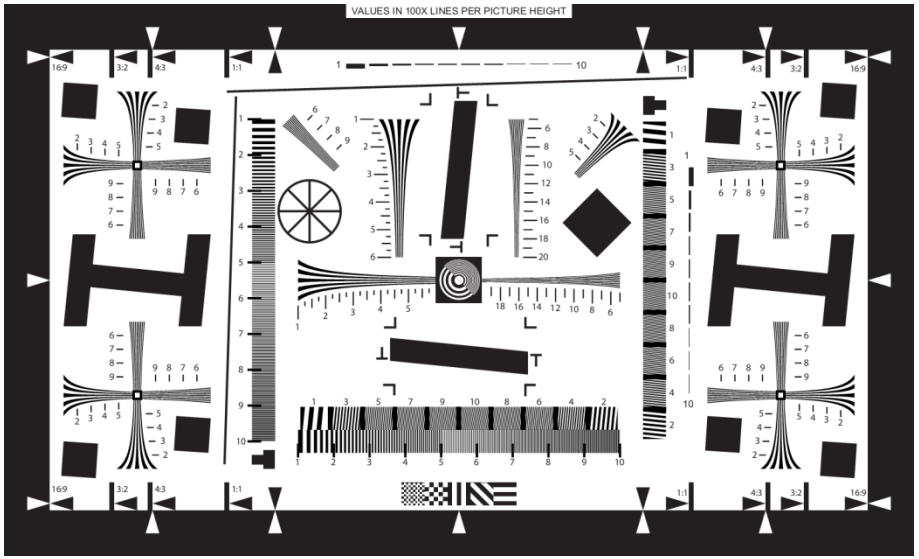
  Use the fluorescent tubes close to the natural light. You are advised to use the Macbeth fluorescent tubes as the D75 and D50 illuminants.
- Articles with rich details and textures

  Prepare articles based on the application scenarios in the section "Definition and Noise."
- (Optional) DNP light box/viewer
- (Optional) Luminance box

Color temperature illuminometer CL-200A

Correction Charts

X-Rite 24-color chart



ISO12233 resolution test chart

Contents

Color

- **Optical filter**

  The sensor photosensitivity is affected when the cutoff frequency of the optical filter varies. If the optical filter is replaced, color correction is required. Ensure that the cutoff frequency offset is not too large.

- **Black level**

  The black level indicates the output luminance of the sensor when there is no external light.

- **White balance/Automatic white balance (AWB)**

  Under the illuminants with various color temperatures, the white color has a blue or red cast. By using the WB algorithm, the strength of R, G, and B channels is adjusted to obtain the actual white color.

- **Color correction matrix (CCM)**

  The sensor and human eyes differ in the response to the spectrum (R, G, and B components). A CCM is used to correct the cross effect and strength of the response to the spectrum, ensuring that the colors of captured images are the same as visual colors.

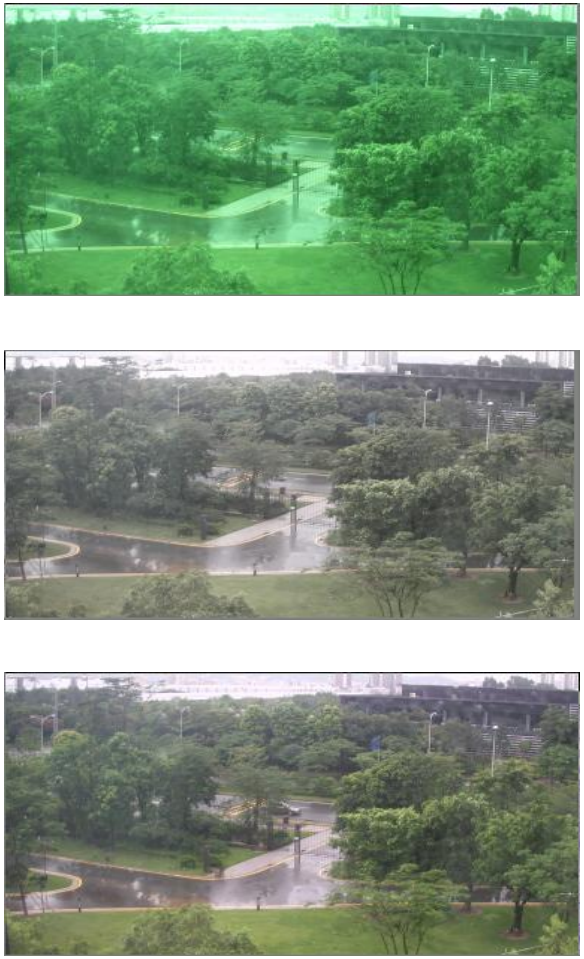
- **Gamma curve**

  The gamma module converts the luminance space in non-linear mode to adapt to the output device.

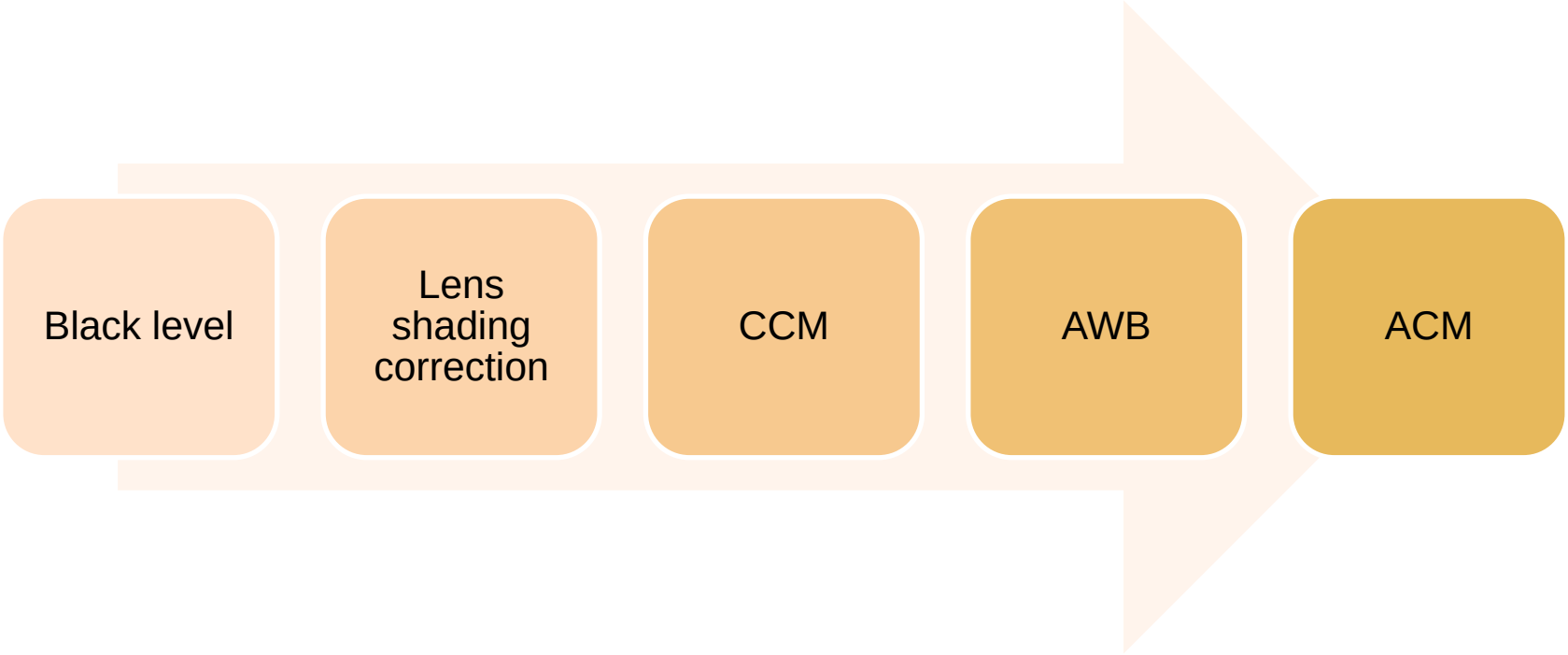
- **Automatic color management (ACM)**

  The ACM is used to adjust colors based on user preferences and styles.

Color



Color Adjustment Procedure



Note:
1. Lens shading correction is bypassed if there is no lens shading.
2. The gamma used by the correction tool must be the same as that used by the program.

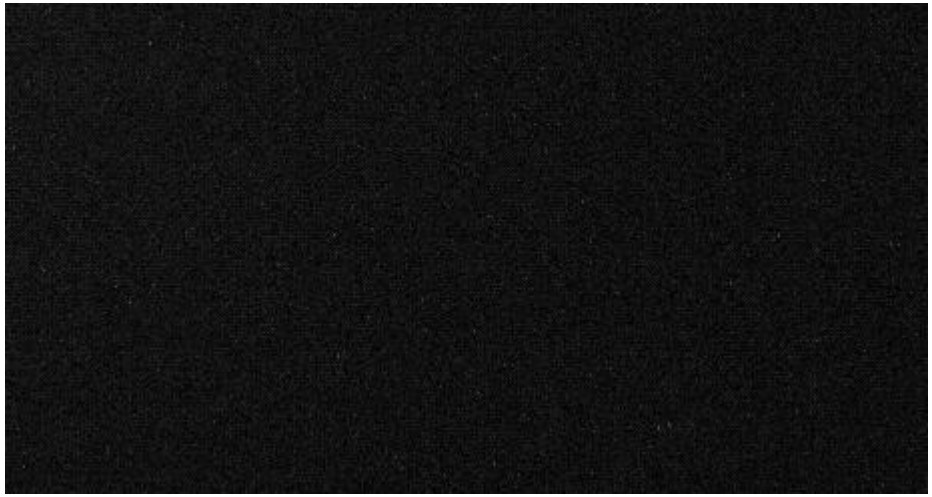
Black Level

Obtain the black level in either of the following ways:

- See the sensor manuals.
- Use the ISP Calibration Tool.

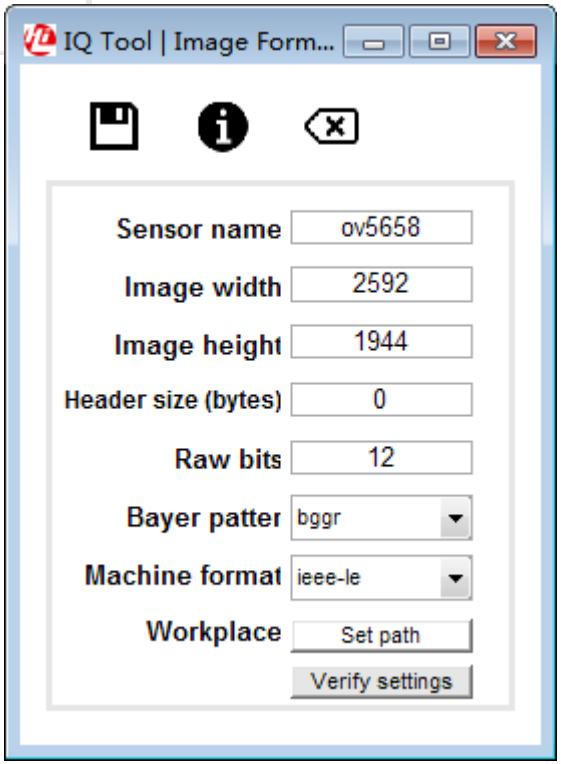
Capturing a Raw Image

- Fully close the iris. Ensure that no lights penetrate the lens.
- Set the analog gain and digital gain to 1x and the exposure time to a small value (such as 10 lines).
- Capture a raw image by using the ITTP_Stream. The 12-bit mode is recommended.
- Rename the image **[***BaseName***].black.gainx1.raw**, and save it in the working directory of the ISP Calibration Tool. [*BaseName*] indicates the customized file name.

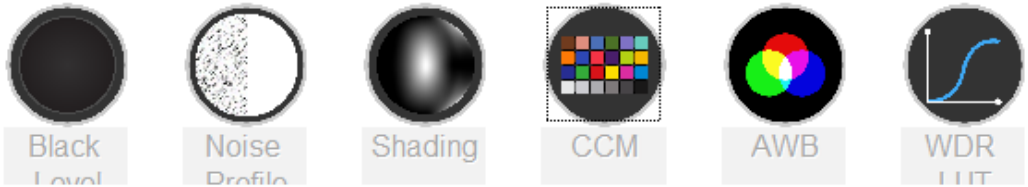


ISP Calibration Tool

- Specify the ISP type, image format, and working path.

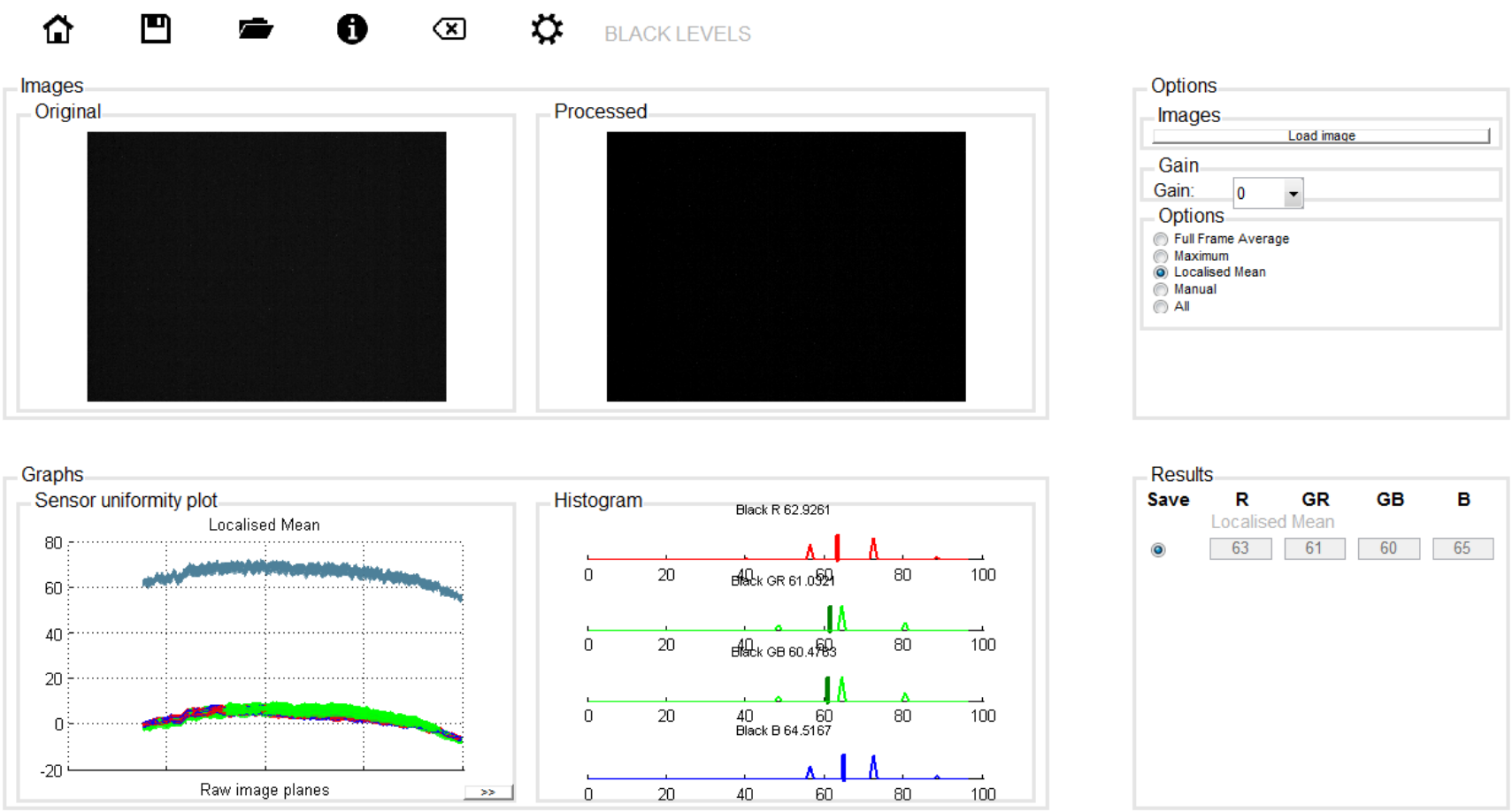


- Click **Black Level**.

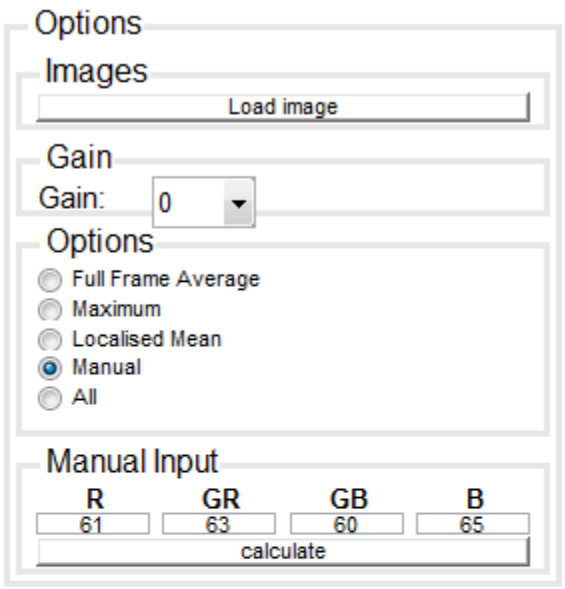


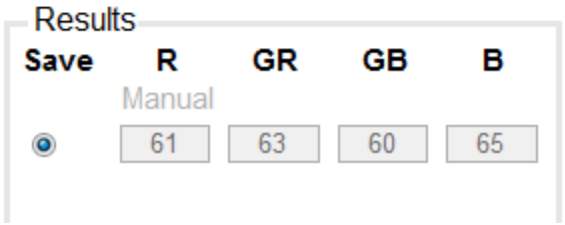
ISP Calibration Tool

- Import a black level raw file.



ISP Calibration





- If you want to generate the black level by using the raw file, select **Localised Mean** in **Options**, click **Load image** to import a raw file, and click **Save**.
- If the black level is obtained from sensor manuals, the black level needs to be manually configured. In this case, select **Manual** in **Options**, enter the black level, click **Calculate**, and then save the result.

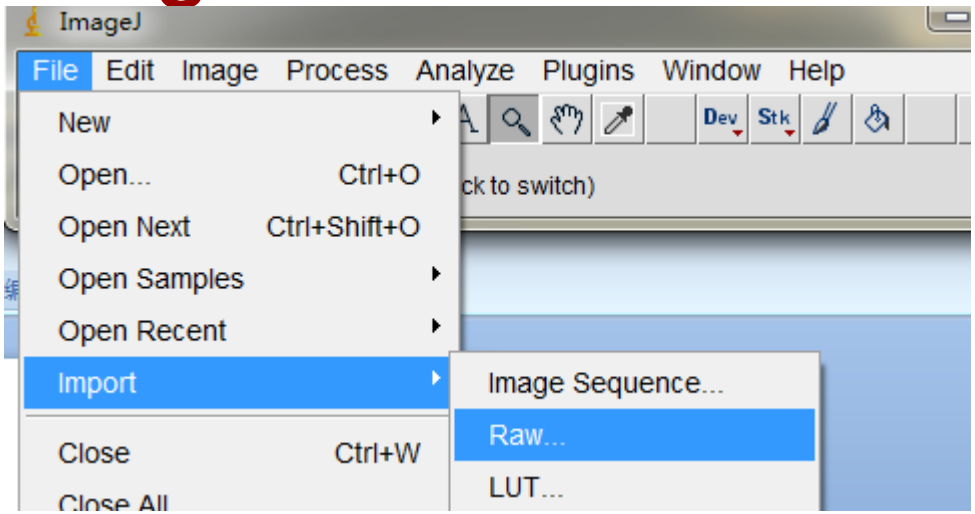
CCM

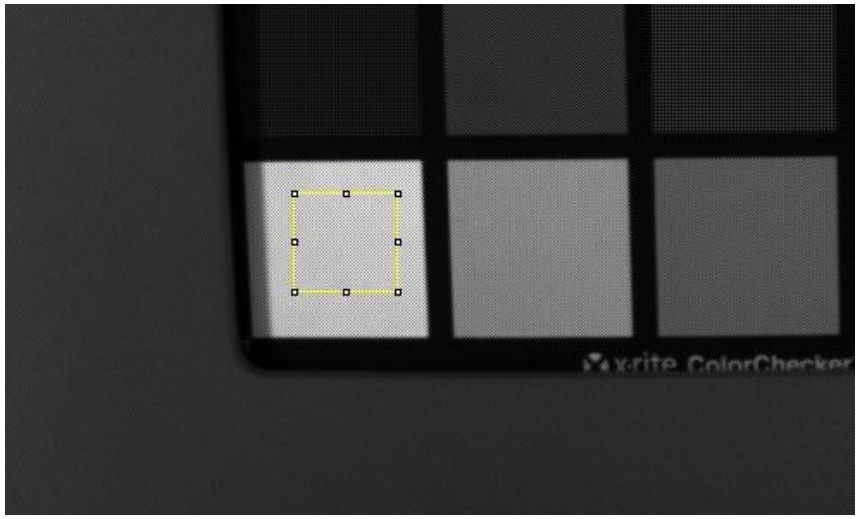
- The CCMs are classified into high, medium, and low color temperature CCMs. The color temperature difference between any two types of CCMs must be greater than or equal to 400ºK.
- In actual scenarios, the optimal CCM is the same at 5000ºK or above, and the required CCM is greatly changed at low color temperatures. Therefore, if there is no specific requirement, it is recommended that correction be performed under the D50, TL84, and A illuminants for the high, medium, and low color temperatures respectively.

Capturing Raw Images (Applying to the CCM and AWB)

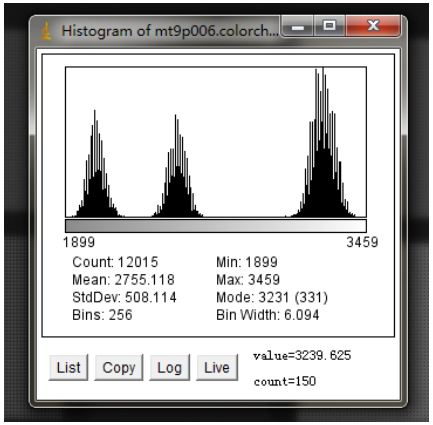
- Under the light box with a specific illuminant, take pictures of a 24-color chart. Note that the distortion should not be too large.
- When the camera is in focus, slightly adjust the camera until the image is a bit blurred. This alleviates the impact on color correction exerted by noises.
- Set **Again** and **Dgain** to the minimum values.
- Adjust the exposure time to enable the luminance in bright regions to be about 80% of the maximum luminance. If the requirement is not met, increase the sensor gain.
- Capture raw images. The 12-bit mode is recommended for all images.
- Rename images **[***BaseName***]. colorchecker.***xxx***.raw**, and save them in the working directory of the ISP Calibration Tool. *xxx* indicates the color temperature of the illuminant, for example, the color temperature of the A, TL84, D50, or D65 illuminant.

Viewing the Luminance of the Raw Image





Open a raw image in ImageJ. Press **H** to view the global statistics, or select a white block shown in the figure in the lower left corner, and then view the peak value of the brightest waveform in the statistics. For example, the total luminance of a 12-bit image is 4096. Therefore, the luminance of the white block is 3276 (80% x 4096).



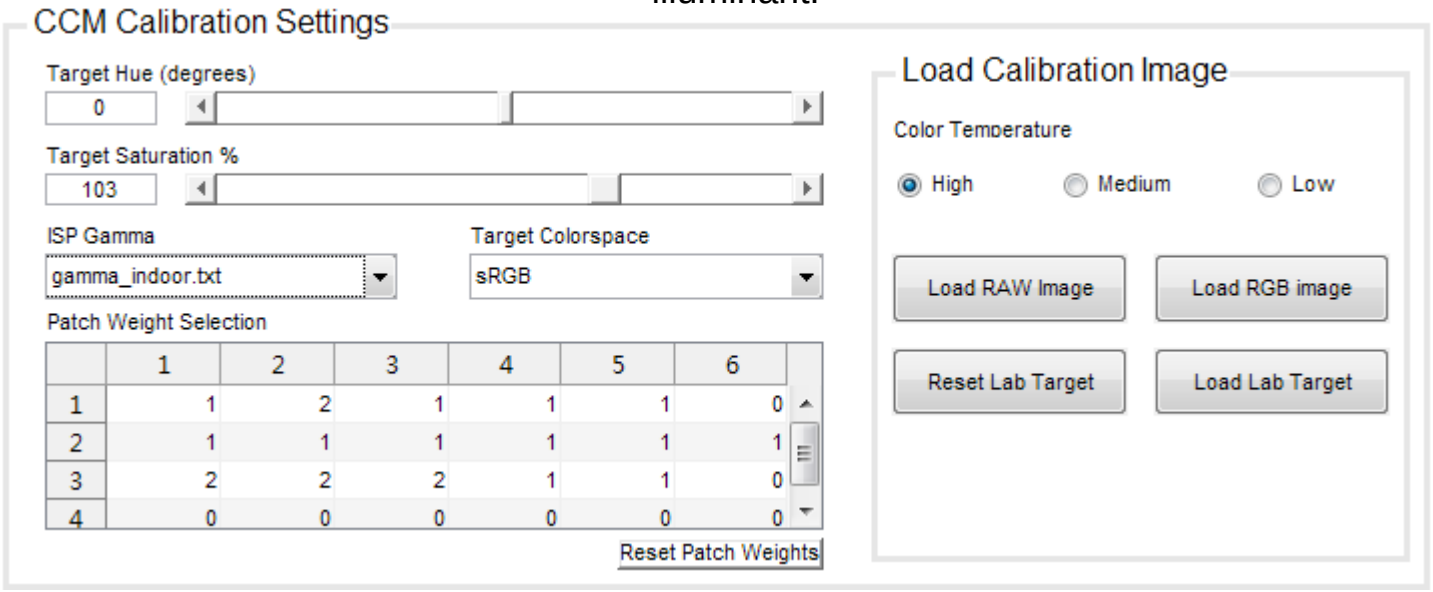
CCM

Correct method (by using the ISP Calibration Tool)

Step 1 In **CCM Calibration Settings**, configure an appropriate weight, set the target saturation to **100**, and import the user gamma in **ISP Gamma**, as shown in the figure below. You can change the hue in **Target Hue** and saturation in **Target Saturation** as required.

Step 2 Select a color temperature type in **Color Temperature**, and click **Load Raw Image**. Go to step 1 each time correction is complete.

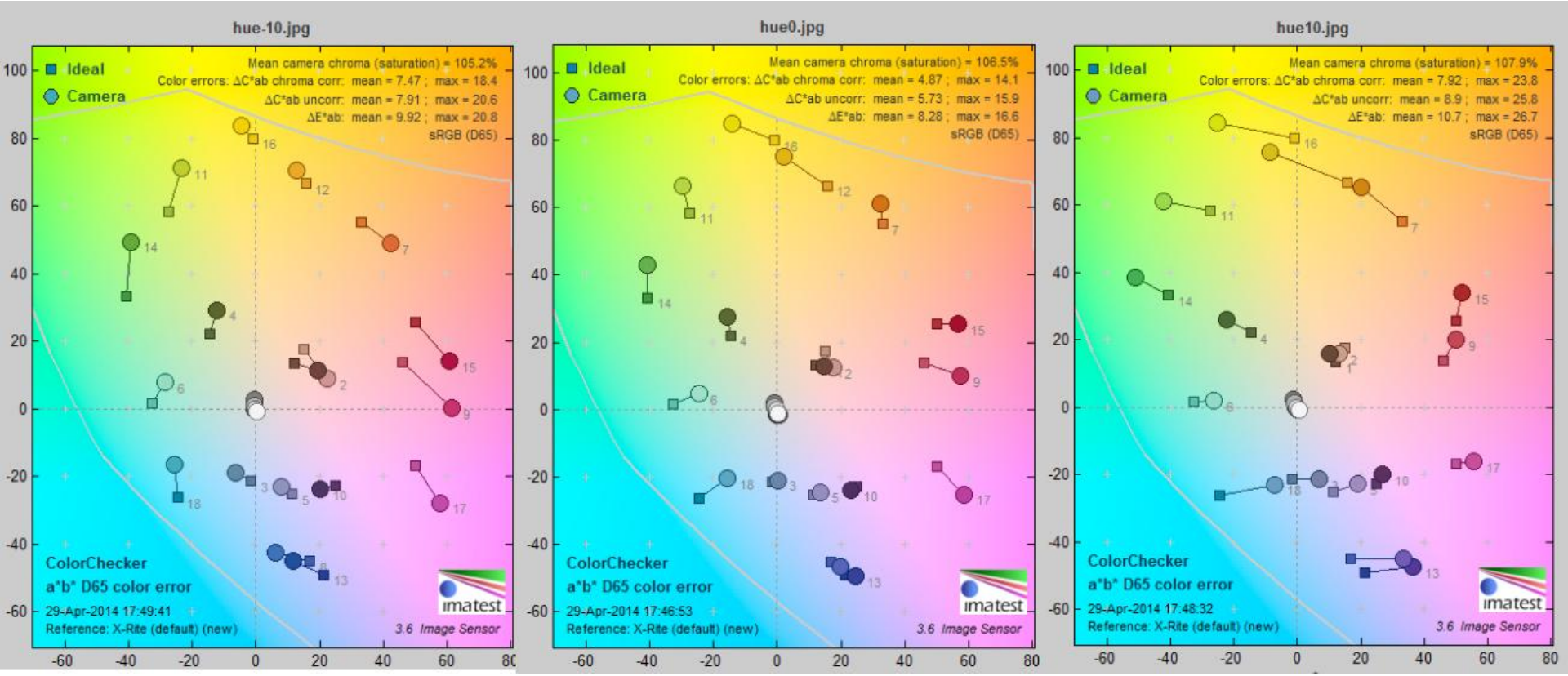
It is recommended that the saturation be set to 90% under the A illuminant.



gamma_indoor.txt

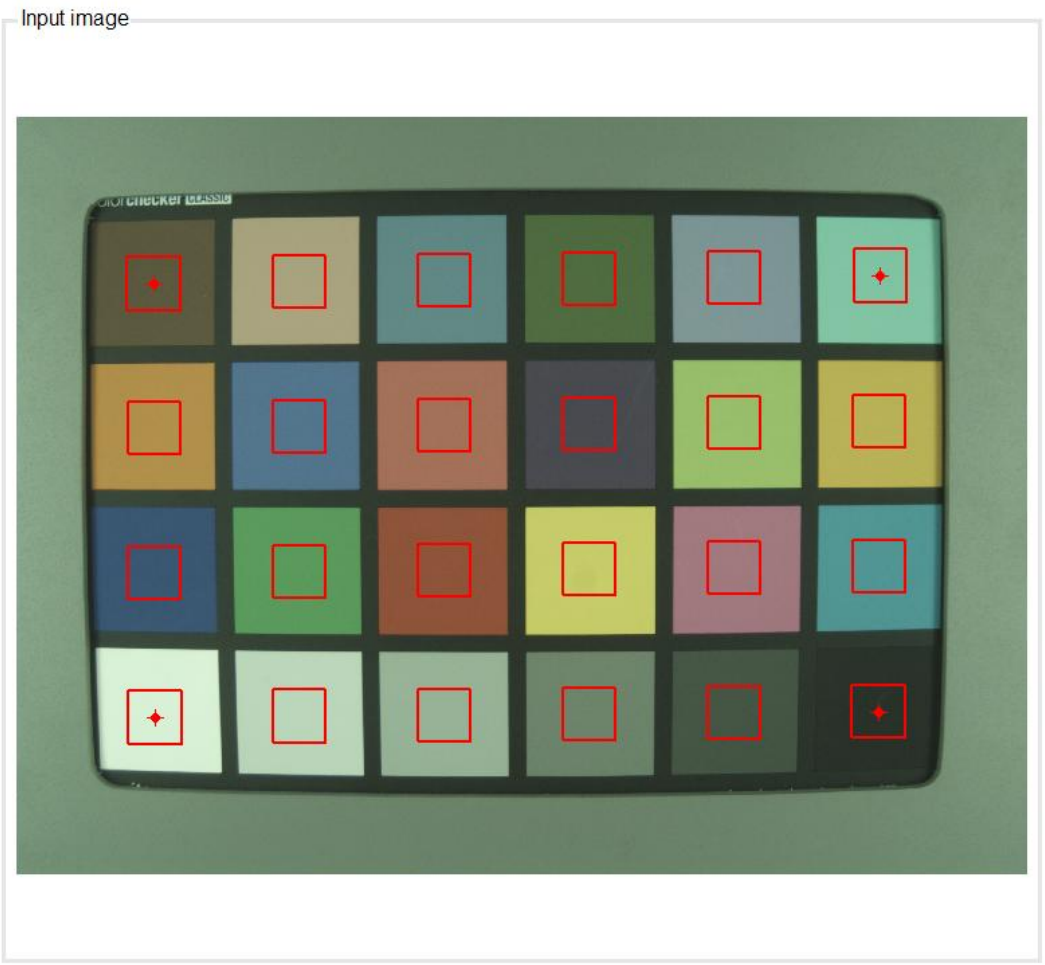
gamma_outdoor.txt

ISP Calibration

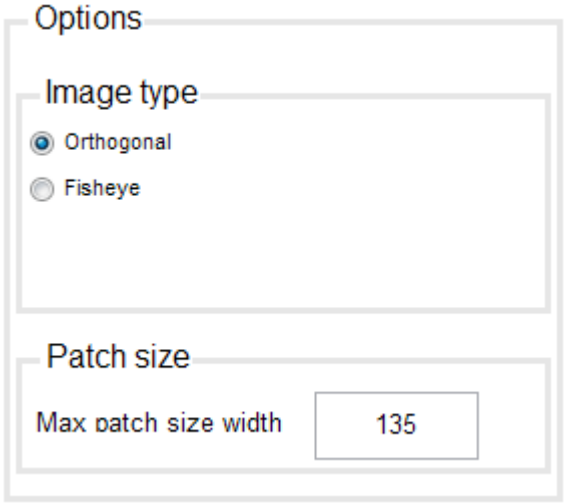


The color can be adjusted by adjusting hue values. When hue values are decreased, they are rotated clockwise; when hue values are increased, they are rotated counterclockwise. You are advised to fine-tune hue values to adjust the color style.

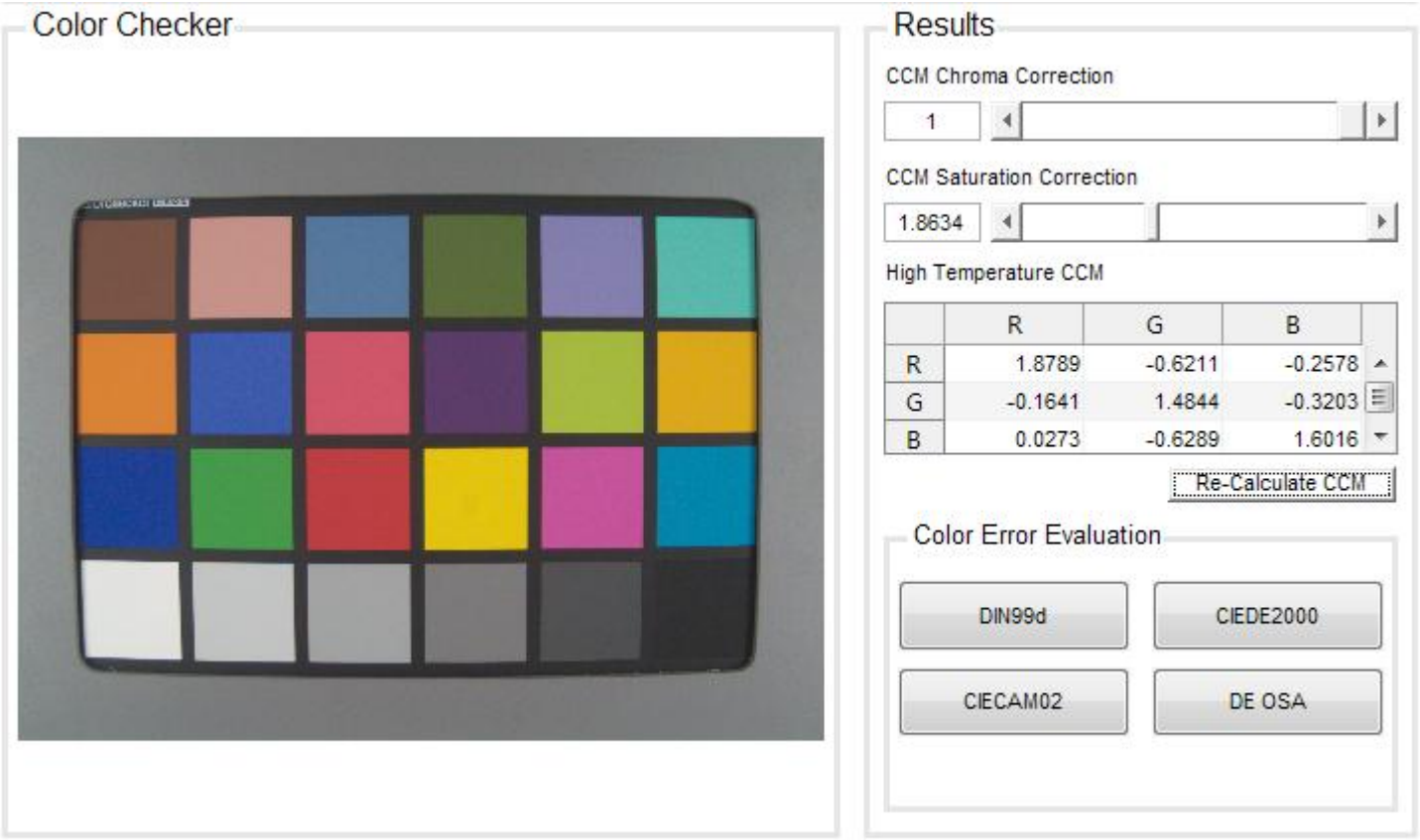
ISP Calibration



After **Load Raw Image** is selected, the **Color Checker Patches** window is displayed. Adjust the red boxes to ensure proper sampling on the 24 color blocks. Then save the settings to close the **Color Checker Patches** window.



ISP Calibration



After the **Color Checker Patches** window is closed, the **IQ Tool | CCM** window is automatically displayed. The previewed result after color correction is displayed in the Color Checker. The calculated CCM values are displayed in **Results**.

Repeat the preceding steps to correct the high, medium, and low color temperature CCMs, save the results, and exit.

Note: The La*b* color error of the ISP Calibration Tool is only for reference, because the error is quite different from the value of Imatest. You are advised to use Imatest directly.

White Balance

- **Static white balance**

  Reference parameter of the white balance algorithm

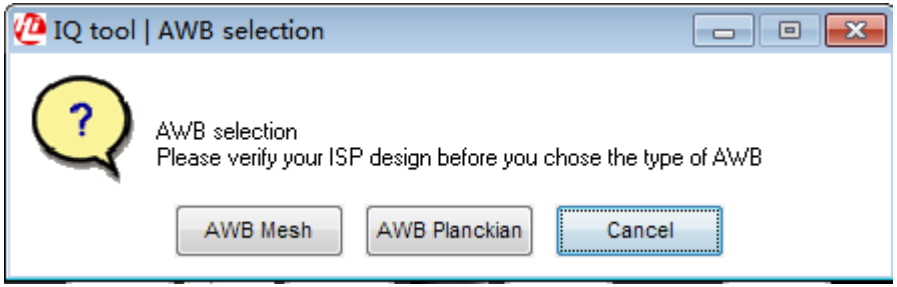
- **AWB**

  Adapting to the correction curves with different color temperatures

Selecting the Color Temperature

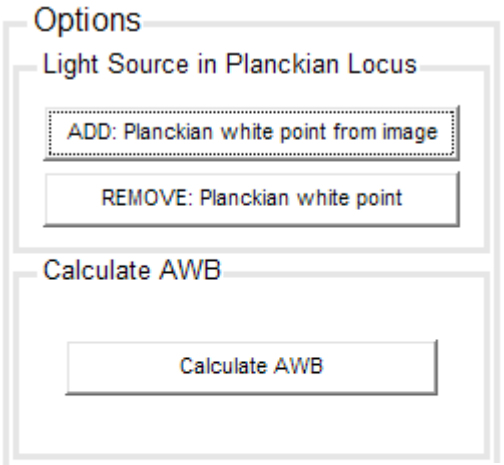
- The color temperature for the static white balance correction is used as the reference color temperature. The illuminants with three types of color temperatures are required for AWB. The medium color temperature is the same as the reference color temperature.
- The closer the actual color temperature to the reference color temperature, the more accurate the color.
- When the actual color temperature falls within any of the three color temperature ranges, the smaller the difference among the three color temperatures, the more accurate the color.
- The color when the actual color temperature falls within any of the three color temperature ranges is more accurate than the color when the actual color temperature is beyond the three color temperature ranges.
- In the actual application scenarios, the typical color temperature range is 2000ºK−9000ºK, and the typical color temperature of the natural light is about 5000ºK in daytime. Therefore, if there is no special requirement, you are advised to select the A, D50, and D75 illuminants to correct white balance. The illuminant with medium color temperature must be D50 even if the fluorescent tubes with other color temperatures are used.

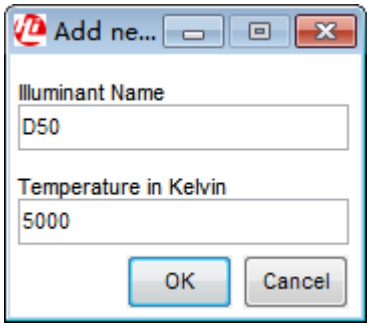
ISP Calibration



Click **AWB** to start the AWB correction. Select **AWB Planckian** to open the **IQ TOOL | AWB Planckian** window.

ISP Calibration





In the **Options** group box of the **IQ Tool | AWB Planckian** window, click **ADD: Planckian white point from image**. Enter the illuminant name and color temperature in the displayed dialog box. Then import the raw images corresponding to the A, D50, and D65 illuminants. See the figure below (the image for D65 is the one with the actual color temperature for D75). Note that the color temperature in **Temperature in Kelvin** is the actual color temperature of the raw image.

Light Source Inputs

Light Source in Planckian Locus

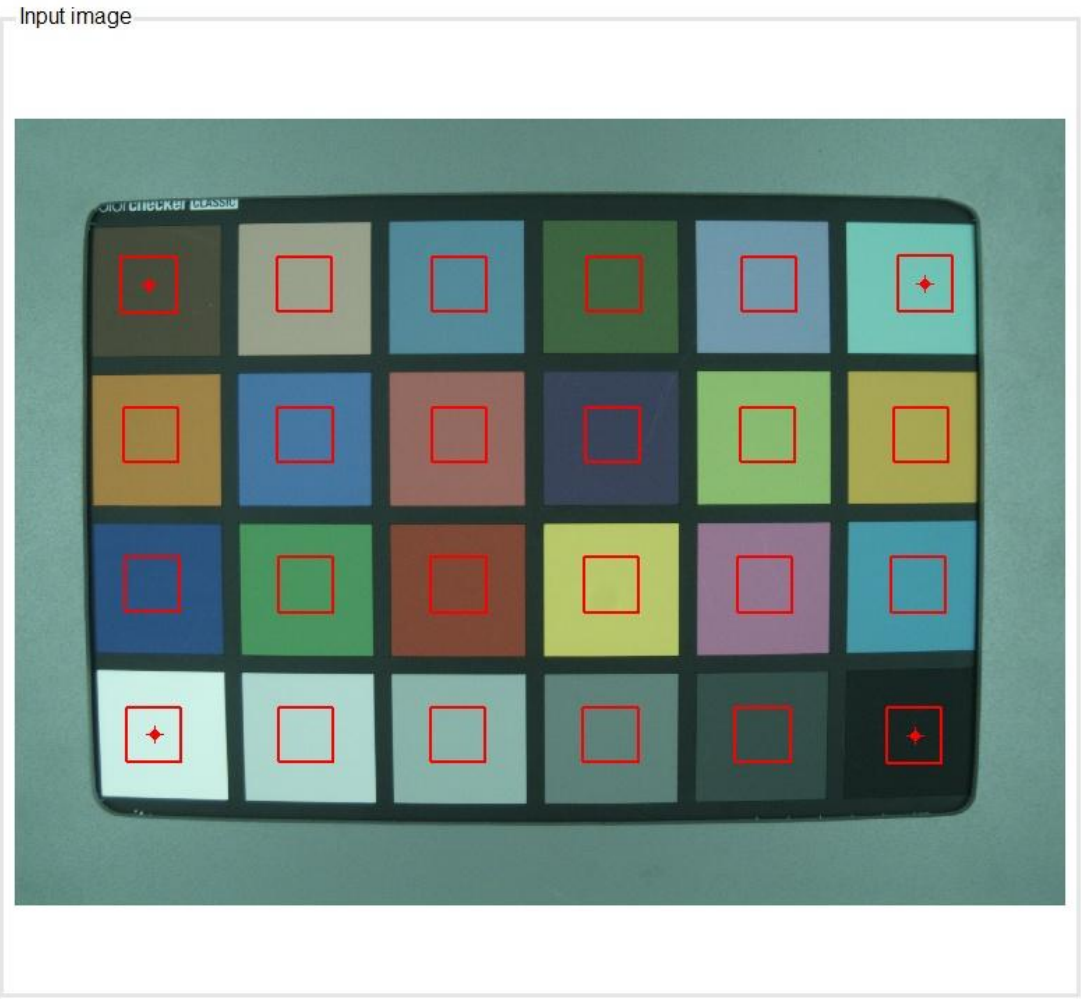
	Illuminant	Temperature	RG	BG
1	D65	6930	0.6074	0.9001
2	D50	4850	0.7044	0.6918
3	A	2470	1.2359	0.4125

ISP Calibration

Note

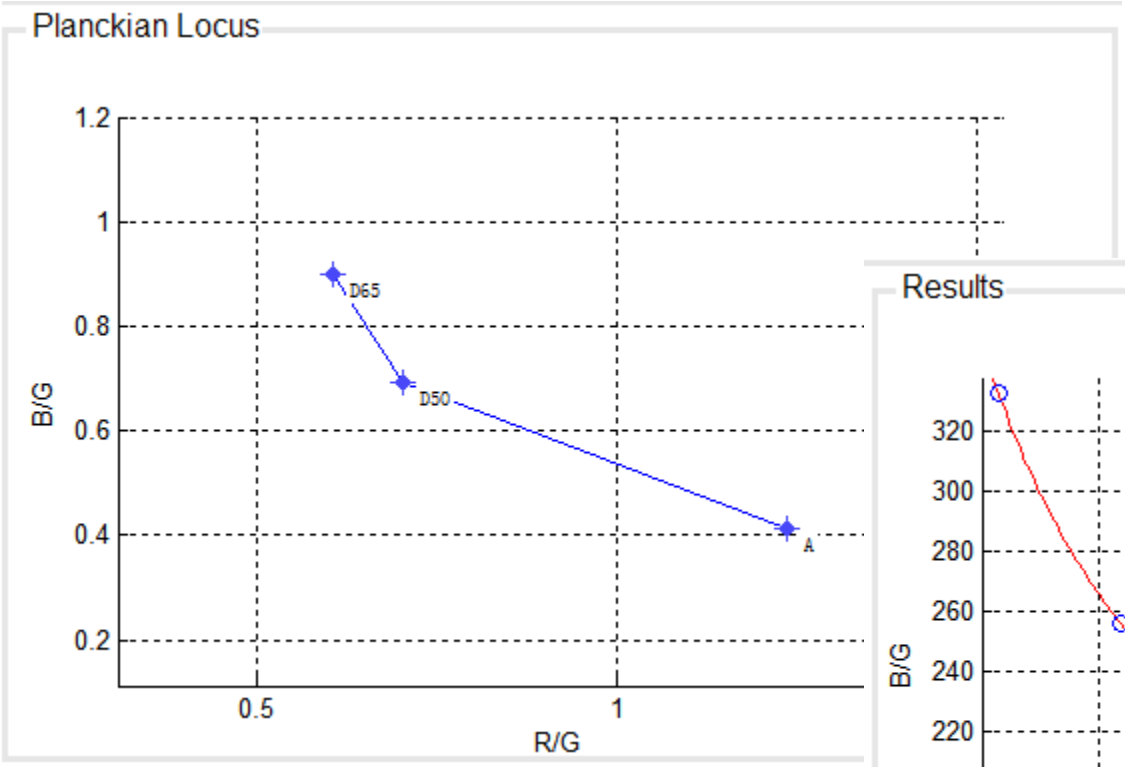
- Enter the tested actual color temperature in **Temperature in Kelvin**.
- The color temperature of a fluorescent tube is variable. There is a 200ºK offset in the period from the time when the fluorescent tube is turned on to the time when the fluorescent tube works stably. The color temperature also changes when a fluorescent tube is used for a long period of time.
- If there is no color temperature meter, perform correction when purchasing fluorescent tubes. A small color temperature offset is acceptable.
- If the image has shading, the white balance parameters can be corrected only after shading correction.

ISP Calibration

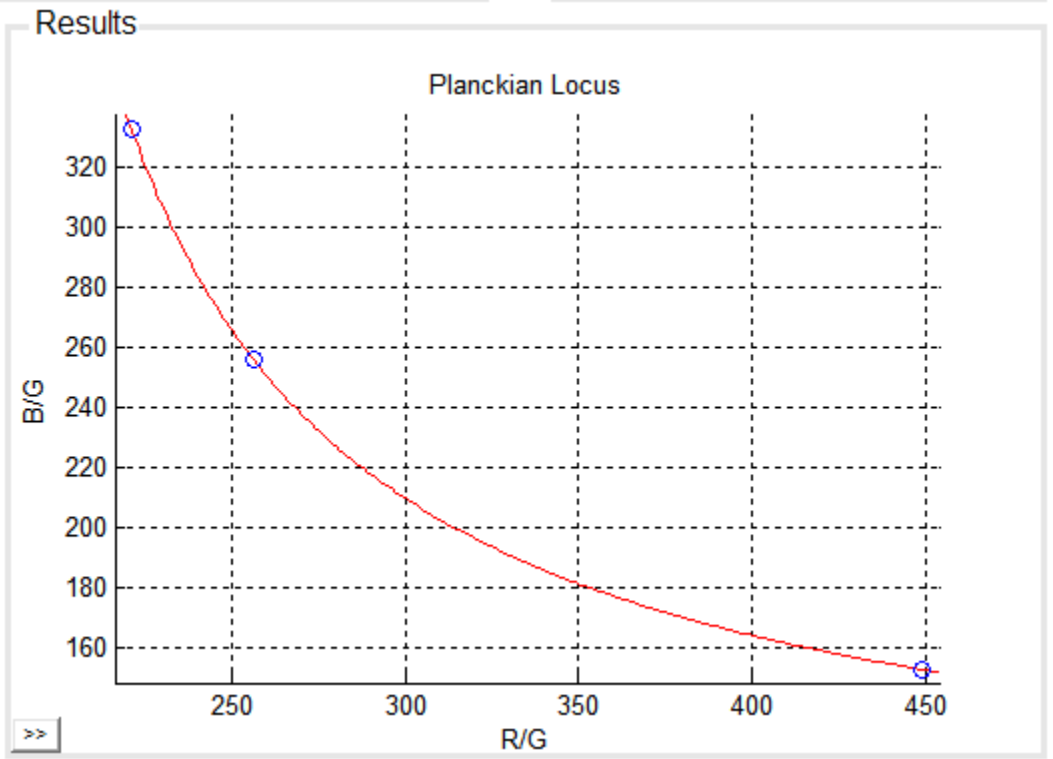


When **ADD: Planckian white point from image** is clicked, the **IQ Tool | Color Checker Patches** window is always displayed. The red boxes need to be adjusted to ensure proper sampling on the 24 color blocks.

ISP Calibration



After three color temperature points are added, the result is automatically generated as follows. Click **Calculate AWB**, and save the result.



ISP Calibration

CCM parameters

The result needs to be saved after each correction. After all corrections are complete, the results need to be saved in the **ISP Calibration Tool** window as files, which facilitates search.

ov5658_calibration_ccm.h

```
12
13  #define MT_ABSOLUTE_LS_D50_CALIBRATE_CCM_LINEAR_R_R 0x01F9
14  #define MT_ABSOLUTE_LS_D50_CALIBRATE_CCM_LINEAR_R_G 0x80B3
15  #define MT_ABSOLUTE_LS_D50_CALIBRATE_CCM_LINEAR_R_B 0x8046
16  #define MT_ABSOLUTE_LS_D50_CALIBRATE_CCM_LINEAR_G_R 0x802C
17  #define MT_ABSOLUTE_LS_D50_CALIBRATE_CCM_LINEAR_G_G 0x01A2
18  #define MT_ABSOLUTE_LS_D50_CALIBRATE_CCM_LINEAR_G_B 0x8076
19  #define MT_ABSOLUTE_LS_D50_CALIBRATE_CCM_LINEAR_B_R 0x0004
20  #define MT_ABSOLUTE_LS_D50_CALIBRATE_CCM_LINEAR_B_G 0x8090
21  #define MT_ABSOLUTE_LS_D50_CALIBRATE_CCM_LINEAR_B_B 0x018C
22
23  #define MT_ABSOLUTE_LS_D40_CALIBRATE_CCM_LINEAR_R_R 0x01BB
24  #define MT_ABSOLUTE_LS_D40_CALIBRATE_CCM_LINEAR_R_G 0x8068
25  #define MT_ABSOLUTE_LS_D40_CALIBRATE_CCM_LINEAR_R_B 0x8053
26  #define MT_ABSOLUTE_LS_D40_CALIBRATE_CCM_LINEAR_G_R 0x8041
27  #define MT_ABSOLUTE_LS_D40_CALIBRATE_CCM_LINEAR_G_G 0x016E
28  #define MT_ABSOLUTE_LS_D40_CALIBRATE_CCM_LINEAR_G_B 0x802D
29  #define MT_ABSOLUTE_LS_D40_CALIBRATE_CCM_LINEAR_B_R 0x8002
30  #define MT_ABSOLUTE_LS_D40_CALIBRATE_CCM_LINEAR_B_G 0x80BB
31  #define MT_ABSOLUTE_LS_D40_CALIBRATE_CCM_LINEAR_B_B 0x01BD
32
33  #define MT_ABSOLUTE_LS_A_CALIBRATE_CCM_LINEAR_R_R 0x01AE
34  #define MT_ABSOLUTE_LS_A_CALIBRATE_CCM_LINEAR_R_G 0x80AA
35  #define MT_ABSOLUTE_LS_A_CALIBRATE_CCM_LINEAR_R_B 0x8004
36  #define MT_ABSOLUTE_LS_A_CALIBRATE_CCM_LINEAR_G_R 0x8039
37  #define MT_ABSOLUTE_LS_A_CALIBRATE_CCM_LINEAR_G_G 0x0142
38  #define MT_ABSOLUTE_LS_A_CALIBRATE_CCM_LINEAR_G_B 0x8009
39  #define MT_ABSOLUTE_LS_A_CALIBRATE_CCM_LINEAR_B_R 0x800F
40  #define MT_ABSOLUTE_LS_A_CALIBRATE_CCM_LINEAR_B_G 0x8156
41  #define MT_ABSOLUTE_LS_A_CALIBRATE_CCM_LINEAR_B_B 0x0265
```

ISP Calibration

Results for the AWB parameter correction

ov5658_calibration.h

```
7
8   /* Calibration results for Black Level */
9   #define BLACK_LEVEL_R_VALUES {1*16, 63}
10  #define BLACK_LEVEL_GR_VALUES {1*16, 61}
11  #define BLACK_LEVEL_GB_VALUES {1*16, 60}
12  #define BLACK_LEVEL_B_VALUES  {1*16, 65}
13  // Calibration results for Static WB
14
15  #define CALIBRATE_STATIC_WB_R_GAIN 0x16B
16  #define CALIBRATE_STATIC_WB_GR_GAIN 0x100
17  #define CALIBRATE_STATIC_WB_GB_GAIN 0x100
18  #define CALIBRATE_STATIC_WB_B_GAIN 0x172
19  /* Calibration results for Auto WB Planck */
```

ov5658_calibration_04-Dec-2014-10.35.08.txt

```
642  %#------ AWB Planckian parameters
643  calParams.AWB_Planckian.WB_static = [ 1.419737  1.445448];
644  calParams.AWB_Planckian.rg_cal = [ 221, 256, 449, ];
645  calParams.AWB_Planckian.bg_cal = [ 333, 256, 153, ];
646  calParams.AWB_Planckian.color_temp_cal  = [ 144, 206, 405, ];
647  calParams.AWB_Planckian.p1 = 0x005E; % in dec 94;
648  calParams.AWB_Planckian.p2 = 0x000F % in dec 15;
649  calParams.AWB_Planckian.q1 = -0x0093 % in dec -147;
650  calParams.AWB_Planckian.a1 = 0x29318 % in dec 168728;
651  calParams.AWB_Planckian.b1 = 0x0080 % in dec 128;
652  calParams.AWB_Planckian.c1 = -0x1D411 % in dec -119825;
653
```

```
E_AWB_P1 0x005E
E_AWB_P2 0x000F
E_AWB_Q1 -0x0093
E_AWB_A1 0x29318
E_AWB_B1 0x0080
E_AWB_C1 -0x1D411
```

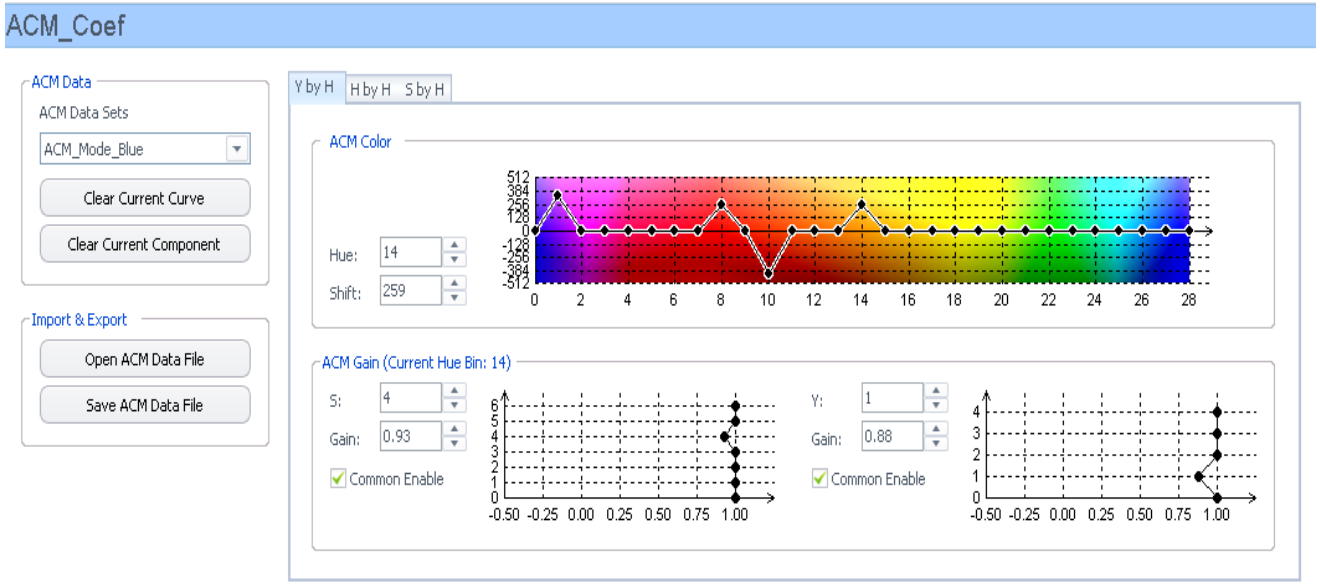
Separate Illuminants

- The separate illuminants can be used to improve the AWB effect under specific illuminants. The white balance is continuously adjusted during AWB and therefore is more accurate than manual white balance. The separate illuminants are not recommended if the environment is uncertain, because the white balance effect in the scenarios with the colors close to the colors of the separate illuminants is affected under other illuminants.
- At the extremely low or extremely high color temperature, you can attempt to add separate illuminants because the risk is relatively low.
- Under the target illuminant, take a raw picture of the 24-color chart. In the **IQ Tool | AWB Planckian** window, select **Add: Planckian white point**, obtain the RG and BG values from **Light Source Inputs**, calculate the reciprocal values of the RG and BG values of the separate illuminant, and then multiply the reciprocal values by 256 respectively. The results are static white balance values and are expressed by **WhiteRgain** and **WhiteBgain**. The results can be checked by using the static white balance for the color temperature of D50. The calibrated parameters can be configured by calling HI_MPI_ISP_SetAWBAttrEx.

ACM

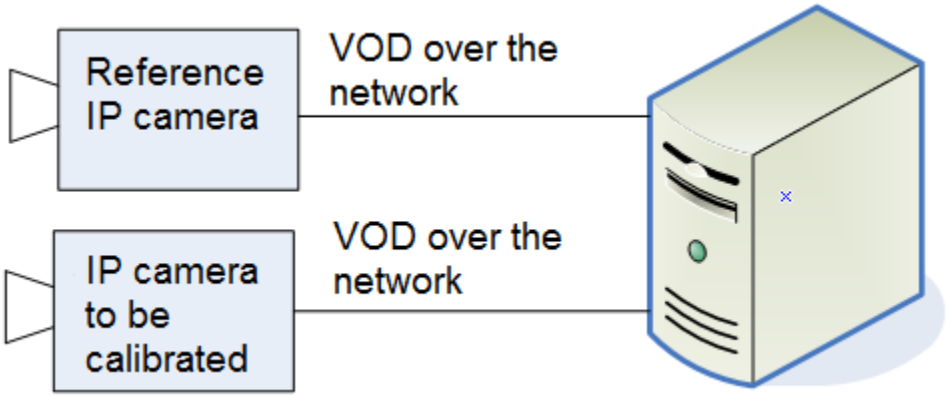
- Concept
  - The ACM is the acronym of automatic color management. The chrominance is the color hue, and the saturation is the color purity.
  - Adjusting the chrominance and saturation of an image improves the color effect and makes the image more colorful.
- Function
  - The difference between color gamuts can be compensated to implement the same display effect on various display terminals.
  - The color can be expressed based on user preferences and styles.

Adjusting the ACM Curve



Select the colors to be adjusted, and adjust the curve based on the color offset.

Copying Colors by Using the ACM



Take pictures of the color chart by using the reference IP camera and the IP camera to be calibrated, calibrate the pictures by using the ACM color copy tool, generate the color adjustment curve and gain, and configure the results to the IP camera to be calibrated. The high-precision color that matches the color of the reference IP camera can be obtained.

Gamma

- Gamma significantly affects the picture quality, that is, different gamma curves indicate different effects.
- Gamma affects the contrast and details in dark regions. A higher contrast indicates that the permeability is better but more details in dark regions are lost.
- Gamma also affects the color. A gamma curve with a higher contrast indicates higher saturation.

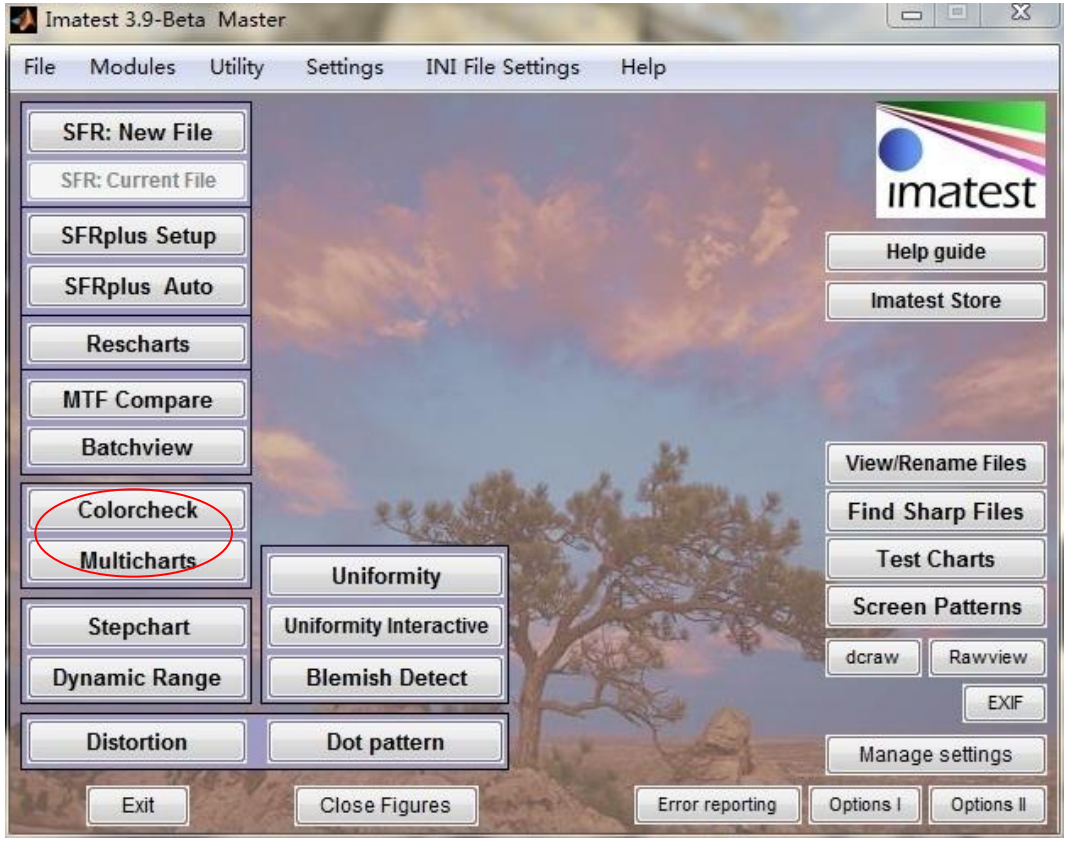
Gamma

- Gamma attributes can be configured by configuring HI_MPI_ISP_SetGammaAttr. For details, see the *HiISP Development Reference*.
- Currently, a set of gamma parameters are adjusted for the indoor and outdoor application scenarios respectively. For details, see the **cmos.c** file.
- You can adjust gamma by using the HiSilicon PQ Tools. You are advised to modify gamma parameters in the existing gamma table. Ensure that the gamma curve varies smoothly.
- The lower the first part of the curve, the higher the contrast.

Color Assessment

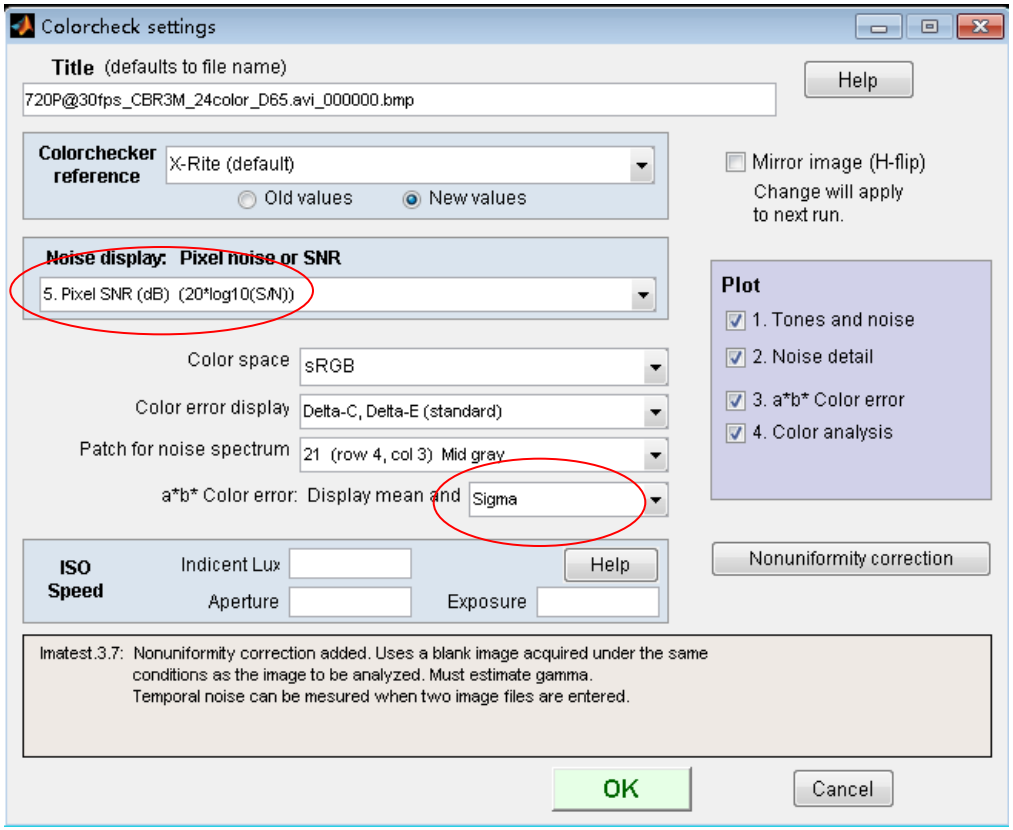
- After color correction, you need to assess the overall effect and fine-tune the unsatisfied parts.
- The color error in the ISP Calibration Tool cannot completely reflect the actual effect.
- The assessments are classified into subjective scenario assessments and objective specifications assessments.
- Objective specifications can be assessed by testing the 24-color chart using the Imatest and HiSilicon PQ Tools. The AWB and color reproduction (CCM) can be tested.

Imatest



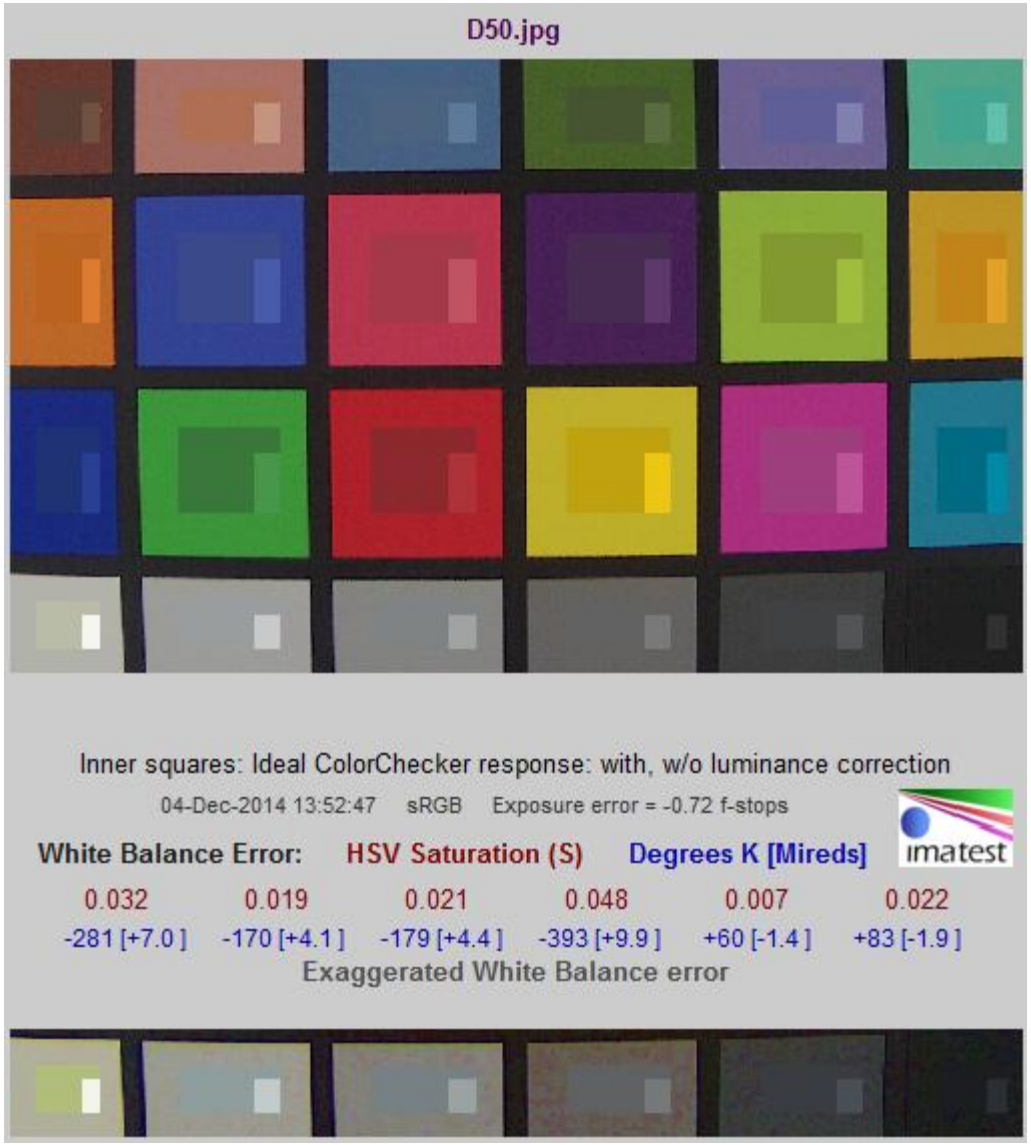
The latest version is recommended.

Imatest


Colorcheck settings
Title (defaults to file name)
720P@30fps_CBR3M_24color_D65.avi_000000.bmp
Help
Colorchecker reference
X-Rite (default)
Old values
New values
Mirror image (H-flip)
Change will apply to next run.
Noise display: Pixel noise or SNR
5. Pixel SNR (dB) (20*log10(S/N))
Plot
1. Tones and noise
2. Noise detail
3. a*b* Color error
4. Color analysis
Color space
sRGB
Color error display
Delta-C, Delta-E (standard)
Patch for noise spectrum
21 (row 4, col 3) Mid gray
a*b* Color error: Display mean and
Sigma
ISO Speed
Indicent Lux
Aperture
Exposure
Help
Nonuniformity correction
Imatest.3.7: Nonuniformity correction added. Uses a blank image acquired under the same conditions as the image to be analyzed. Must estimate gamma.
Temporal noise can be mesured when two image files are entered.
OK
Cancel

White Balance

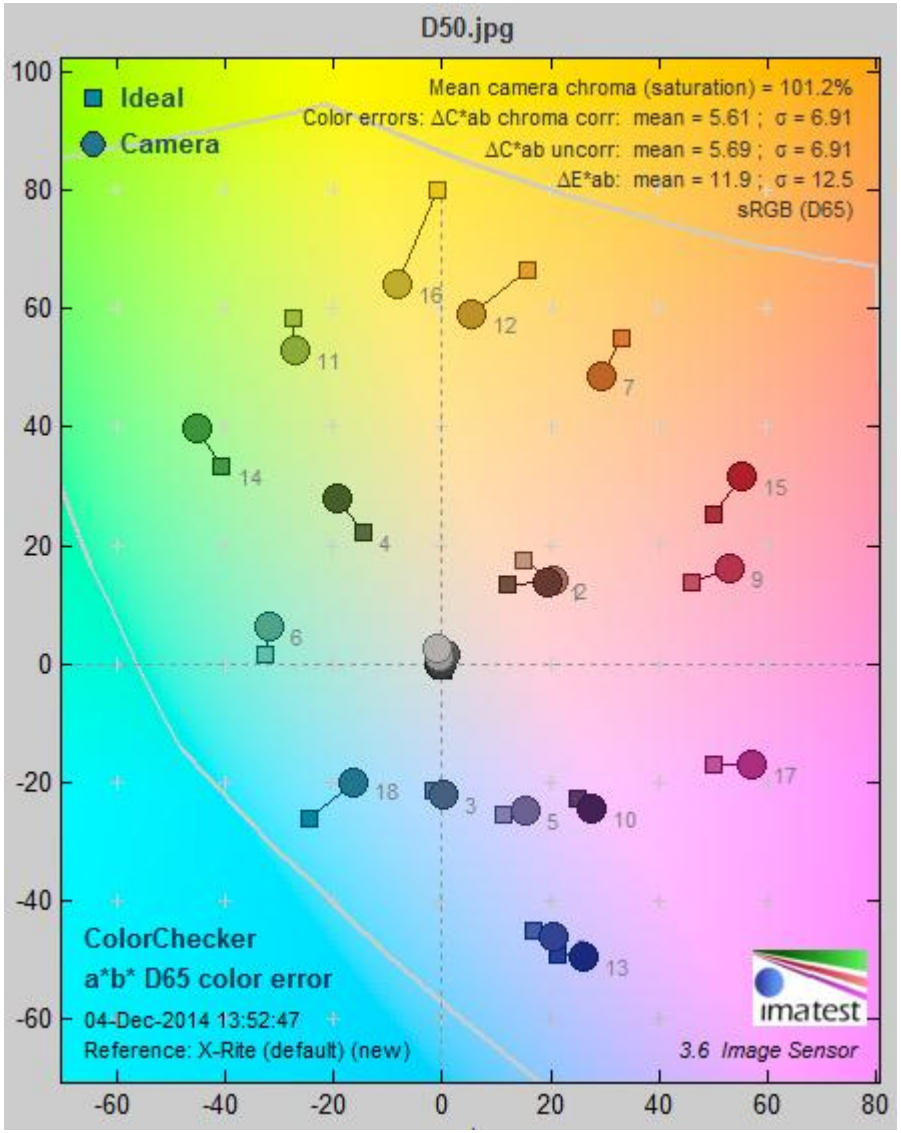
- Use the maximum S value among the white grids 2-4 at the bottom as the white balance specifications. The requirement is met if S is less than 0.10.
- Test the white balance at various color temperatures under different illuminants such as A, TL84, D50, and D75.



Imatest

△C(σ)	< 10
△E(σ)	< 15
Sat	100−130

Test the white balance and color reproduction at as many color temperatures as possible when assessing the color.



Contents

Definition and Noise

As the definition and noise are contradictory in most cases, you need to balance them according to your preferences.

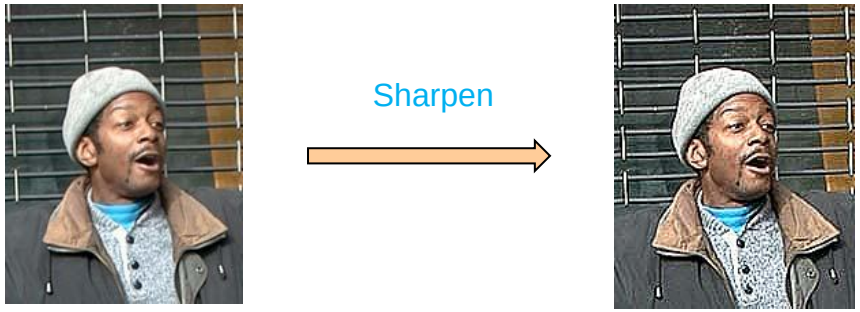
Definition

- **Edge sharpness**

  The definition of large edges mainly affects subjective feelings.

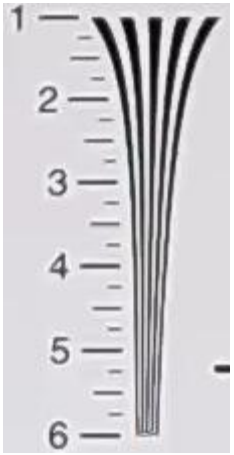
- **Resolution**

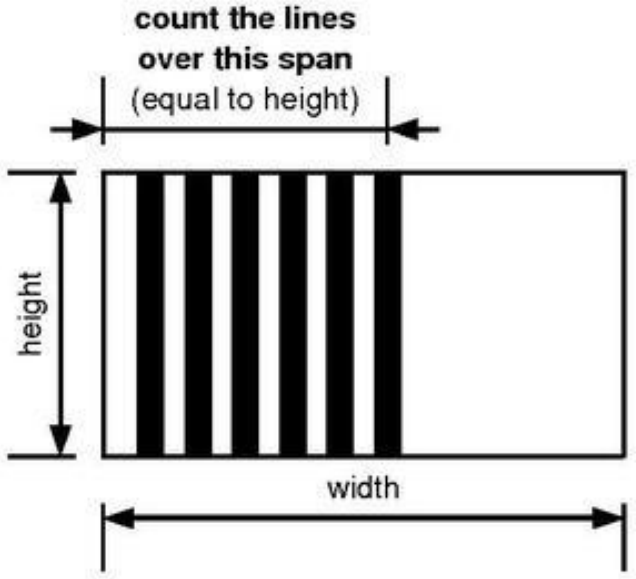
  The resolution reflects texture details.



Resolution

As a concept inherited from the analog camera, the resolution refers to the maximum number of identified horizontal black and white lines in the length of the image height. It is measured by television line (TVL).





Factors Affecting the Definition

- **Optical filter**

  The optical filters with the optical low-pass filter (OLPF) function reduce the horizontal or vertical resolution to different extents. The impacts vary according to the OLPF direction. The OLPF directions include horizontal, vertical, and horizontal/vertical. The optical filters with the horizontal direction affect the horizontal resolution, the optical filters with the vertical direction affect the vertical resolution, and the optical filters with the horizontal/vertical directions affect both horizontal and vertical resolutions. The optical filters without the OLPF function do not affect the resolution.

- **Lens**

  When the sensor resolution is greater than the lens resolution, the maximum image resolution is the lens resolution. For example, the resolution of the 1080p sensor lens must be greater than 200 megapixels; otherwise, the image resolution is reduced. Therefore, the lens resolution must be greater than or equal to the sensor resolution.

- **Demosaic**

  Demosaic is an image processing module of the ISP. The parameter values of the demosaic module affect the image resolution.

- **Sharpen and Denoise**
  - The sharpen strength and denoising strength change when the gain changes.
  - VPSS

Factors Affecting the Noise

- **Fixed pattern noise (FPN)**

  Due to the process of complementary metal-oxide semiconductor (CMOS) sensors, the images of some sensors may have fixed row noises or column noises, and obvious green vertical stripes appear in low illumination. Before resolving this issue, you need to check whether sensor vendors provide related configuration sequences for reducing this type of noises. You can also remove FPNs by using the FPN removal module of the Hi3516A/Hi3516D. For details, see the *HiISP Development Reference*.

- **Power supply**

  The power noises are presented as horizontal stripes on the image, which are caused by the large fluctuation of the voltage of the sensor power supply or the offset between the phases of the sensor clock source and the master chip clock.

- **Noise profile**

  The noise profile is the sensor noise pattern and can be considered as the sensor noise feature. The noise profile varies according to the sensor model. In the ISP code, the noise profiles are listed in a noise profile table. The noise profile and denoise module determine the denoising strength.

- **Demosaic**

  Demosaic is an image processing module of the ISP. The parameter values of the demosaic module affect the image noise.

- **Sharpen and denoise**

  The sharpen strength and denoising strength change when the gain changes.

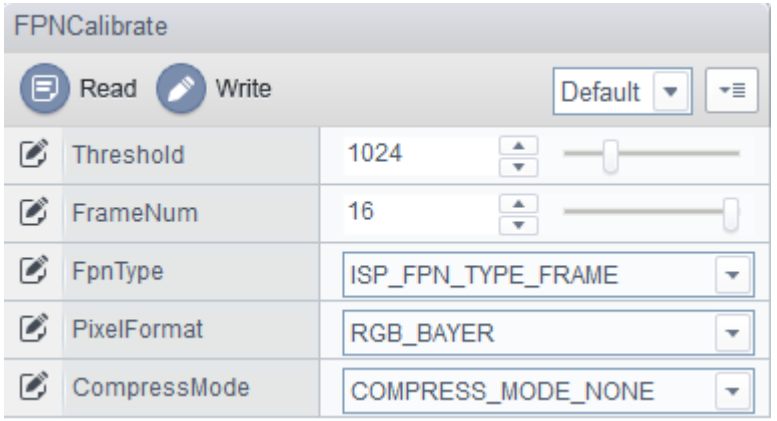
- **VPSS**

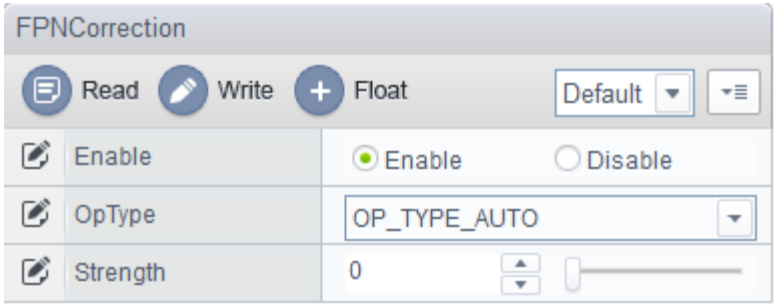
FPN

Correction method

(by using the HiSilicon PQ Tools)

The environment must be completely black by closing the iris or by other means for the FPN correction. The parameter values on the right are recommended. On the **FPN Calibrate** page, click **Write** to start the correction. After the correction, select **Enable** on the **FPN Correction** page. It is recommended that **OpType** be set to **OP_TYPE_AUTO**. Then the FPN effect can be viewed.



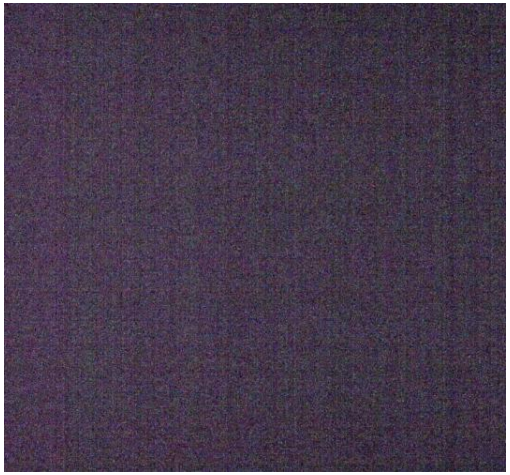


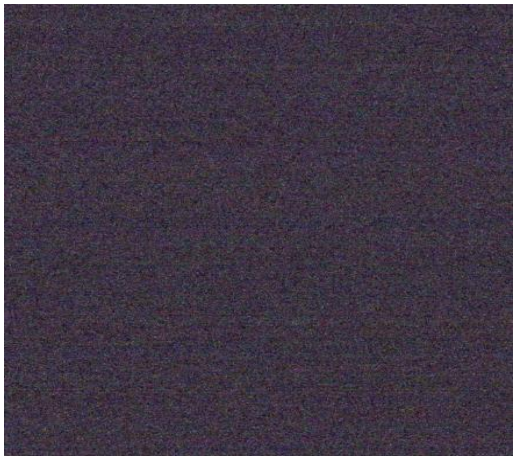
FPN

Correction method

(by using the HiSilicon PQ Tools)

The figure in the upper part is an image with FPNs, and the figure in the lower part is the one whose FPNs are removed after correction.





Noise Profile

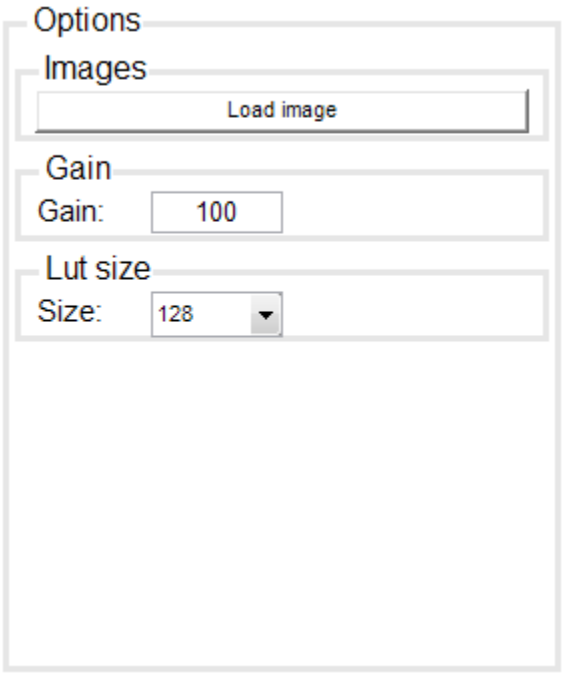
Correction method

(by using the ISP Calibration Tool)

The noise profile correction depends on the black level. Select the raw image that is taken under the D50 illuminant. The ISP Calibration Tool automatically calculates the result.

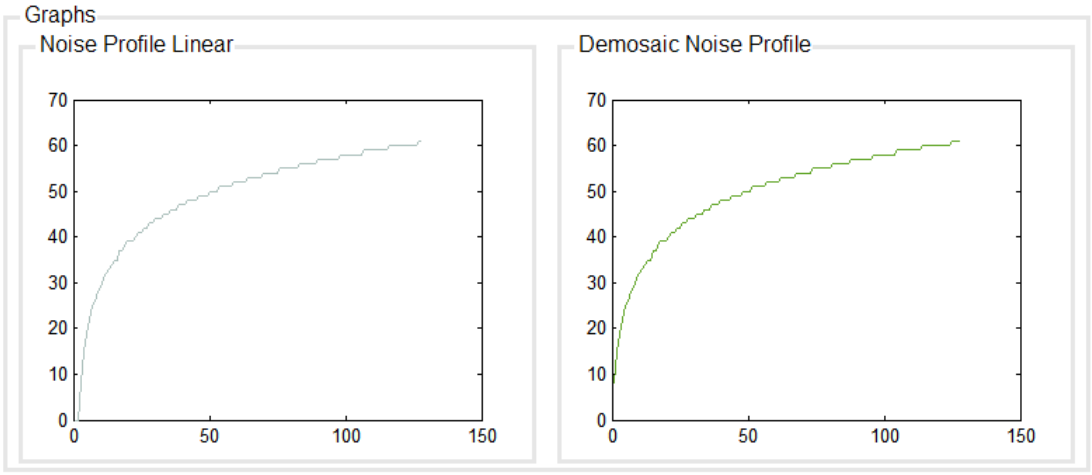
Note that the image must be a 12-bit raw image for this correction. The 10-bit sensor also needs to capture a 12-bit raw image.

On the **IQ Tool | Noise Profile** page, click **Load Image** in **Options**, select the Color Checker for D50, adjust the sampling position of color blocks, and save the settings. Then the result is obtained.



Noise Profile

On the **IQ Tool | Noise Profile** page, click **Save** and then close the page. On the main GUI of the ISP Calibration Tool, click **Save**, and then search results in the saved file. As shown in the figure on the right, search for **NP_LUT** and **dmsc_NP_lut**, and enter them in the code of **cmos.c**.



ov5658_calibration_04-Dec-2014-15.18.08.txt

```
16  %#------ NOISE_PROFILE_LINEAR parameters
17  calParams.NOISE_PROFILE_LINEAR.NP0.g1x =  0.000062 ;
18  calParams.NOISE_PROFILE_LINEAR.NP1.g1x =  0.012000 ;
19  calParams.NOISE_PROFILE_LINEAR.lut_size.g1x =  128 ;
20  calParams.NOISE_PROFILE_LINEAR.NP_LUT.g1x = [0, 0, 8, 15, 19, 22, 25, 26,
21  calParams.NOISE_PROFILE_LINEAR.dmsc_NP_lut.g1x = [8, 15, 19, 22, 25, 26,
22  %In hex
23  calParams.NOISE_PROFILE_LINEAR.NP_LUT.g1x = [0x0, 0x0, 0x8, 0xF, 0x13, 0x
24  calParams.NOISE_PROFILE_LINEAR.dmsc_NP_lut.g1x = [0x8, 0xF, 0x13, 0x16, (
```

Demosaic

Correction method

Use the ISO12233 resolution test chart.

Demosaic

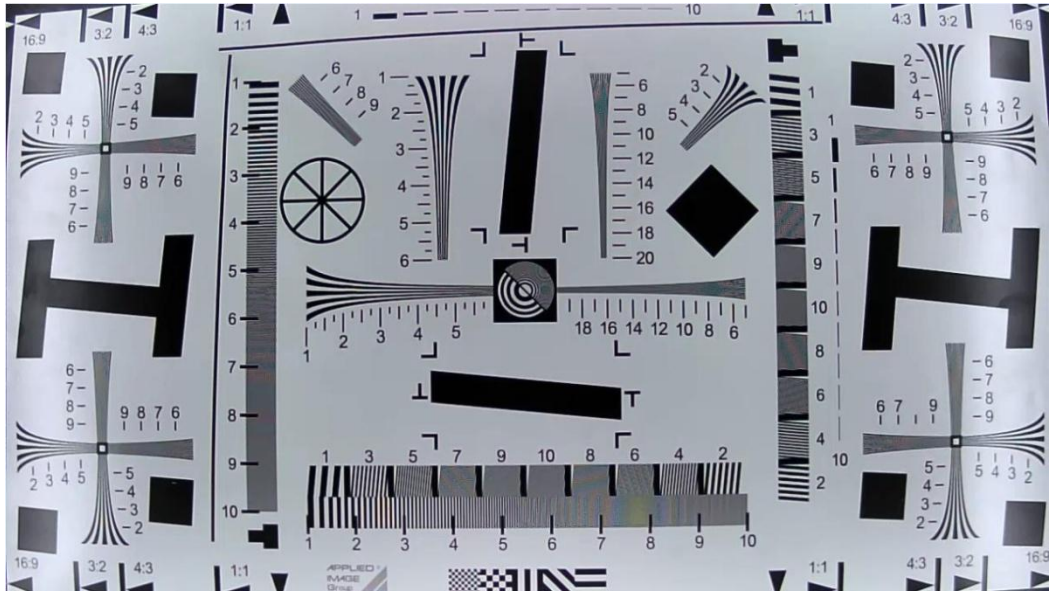
The following are the prerequisites for demosaic correction:

- The black level has been correctly configured.
- The noise profile has been calibrated.
- snr_thresh has been correctly configured, and the denoise module has been enabled.
- Dynamic range compression (DRC) has been disabled.
- A target resolution has been selected. The resolution must be greater than 650 TVLs for the 720p IP camera, 900 TVLs for the 1080p IP camera, 1300 TVLs for the 3-megapixel (4:3) IP camera, or 1600 TVLs for the 5-megapixel IP camera.

Demosaic

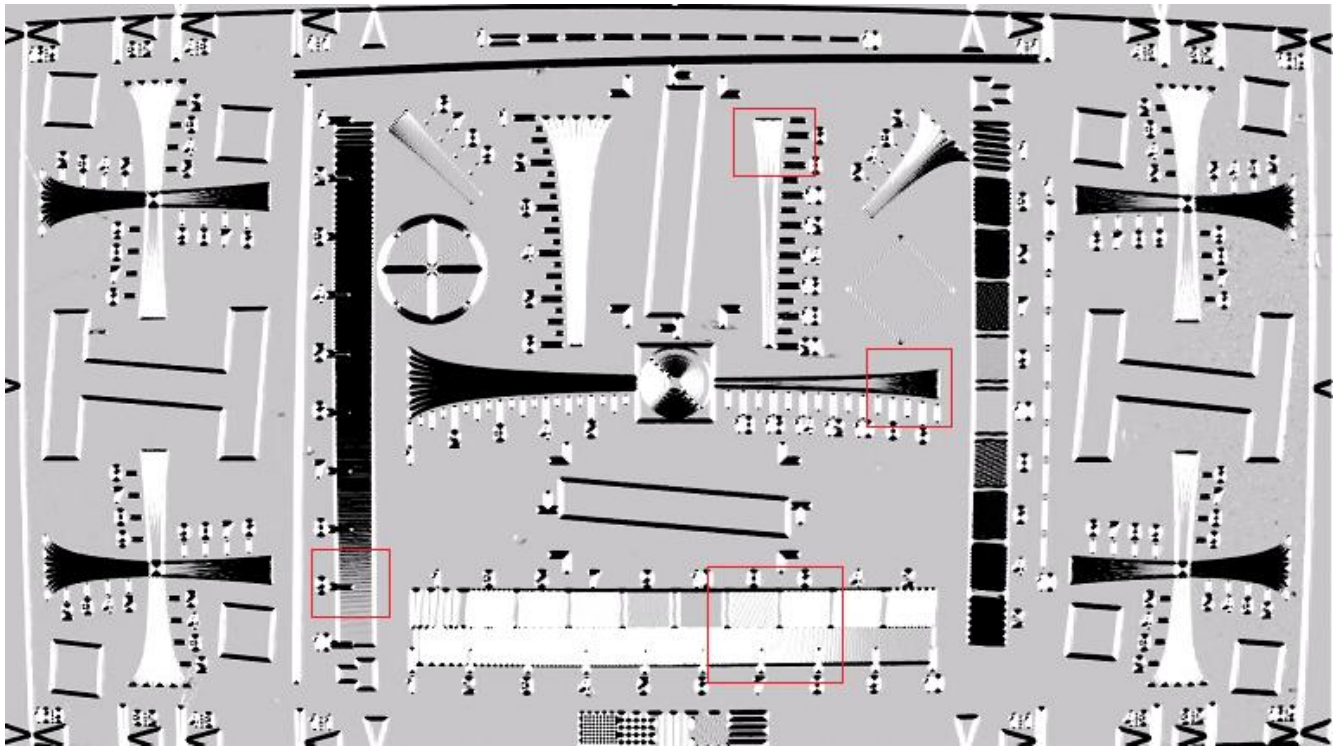
Typically, the default values of **U8VhSlope**, **u8AaSlope**, and **u8VaSlope** are used. If a new sensor is connected, do as follows:

- Select a target resolution. The resolution must be greater than 650 TVLs for the 720p IP camera, 900 TVLs for the 1080p IP camera, 1300 TVLs for the 3-megapixel IP camera, or 1600 TVLs for the 5-megapixel IP camera.
- Take a picture of the ISO12233 chart while the chart fully occupies the screen and the lens is in focus.
- **u8SatSlope** = **0x5d**
- **u16SatThresh** = **0x00**
- **u8AcSlope** = **0xa0**
- **u16AcThresh** = **0x1b3**
- **u16UuThresh** = **0x08**



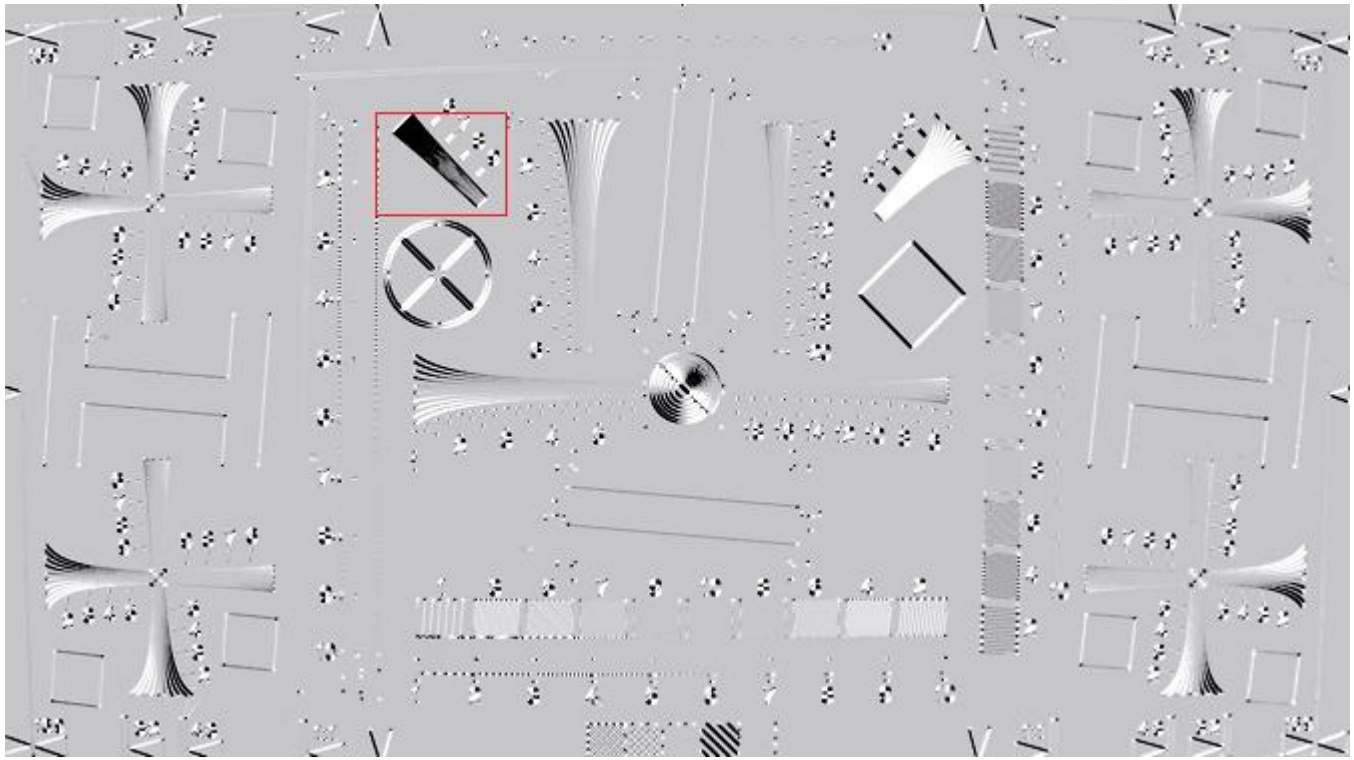
Demosaic VH

- Set **DemosaicConfig** to **ISP_DEMOSAIC_CFG_VH** and **u16VhThresh** to **0**.
- Adjust **u8VhSlope** until the horizontal and vertical resolutions are target values.



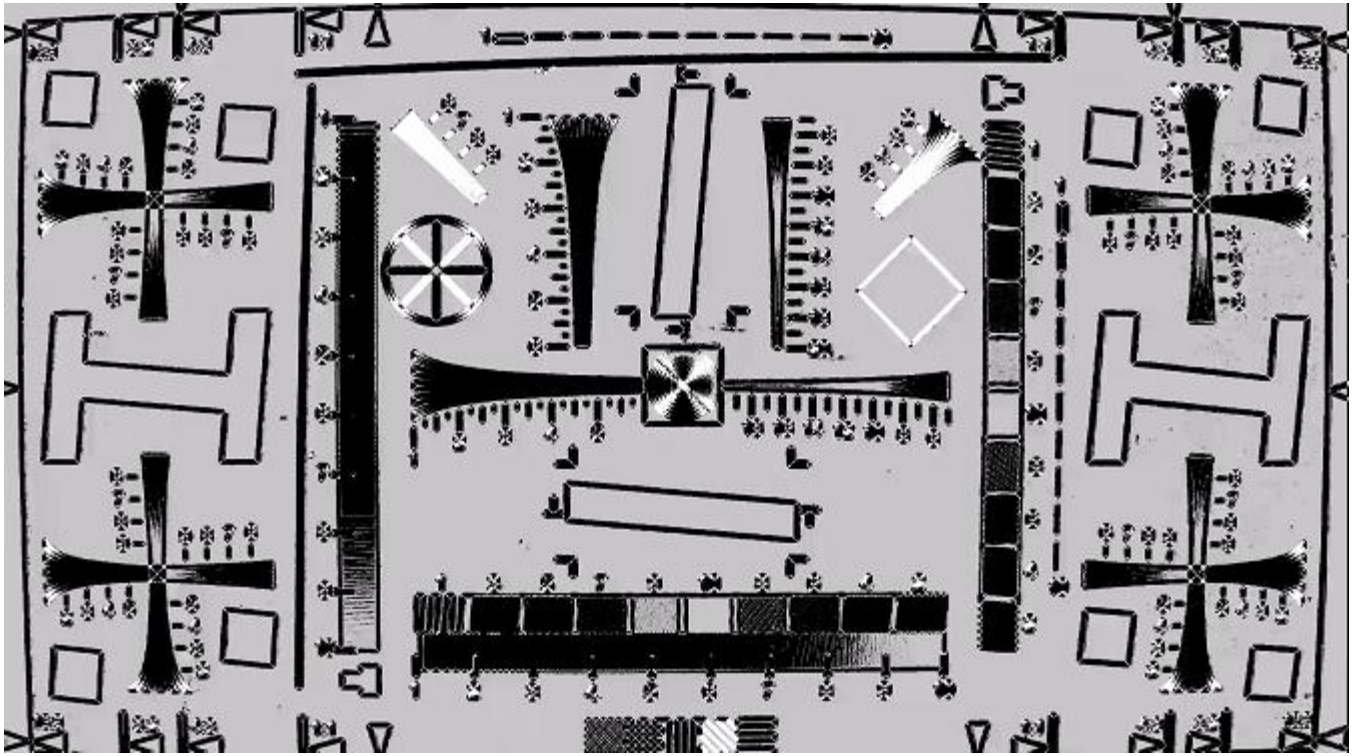
Demosaic AA

- Set **DemosaicConfig** to **ISP_DEMOSAIC_CFG_AA** and **u16AaThresh** to **0**.
- Adjust **u8AaSlope** until the slant resolution is 50 TVLs less than the target value.



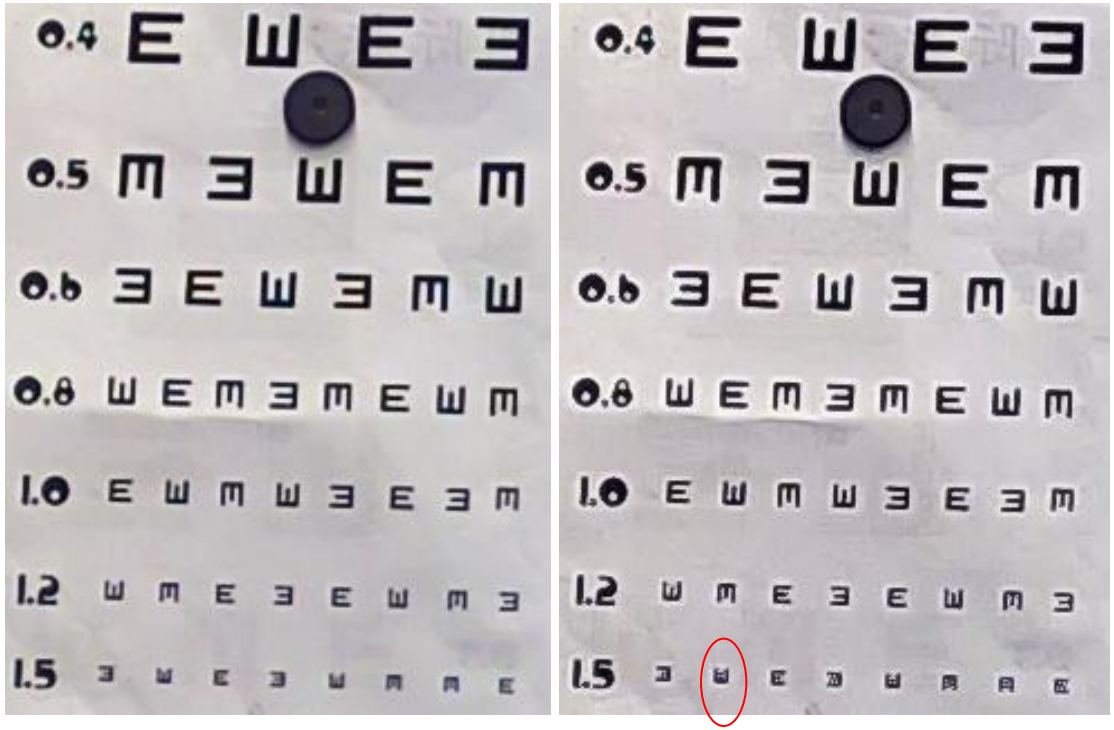
Demosaic VA

- Set **DemosaicConfig** to **ISP_DEMOSAIC_CFG_VA** and **VaThresh** to **0**.
- Adjust **u8VaSlope** until the resolution is the target value.



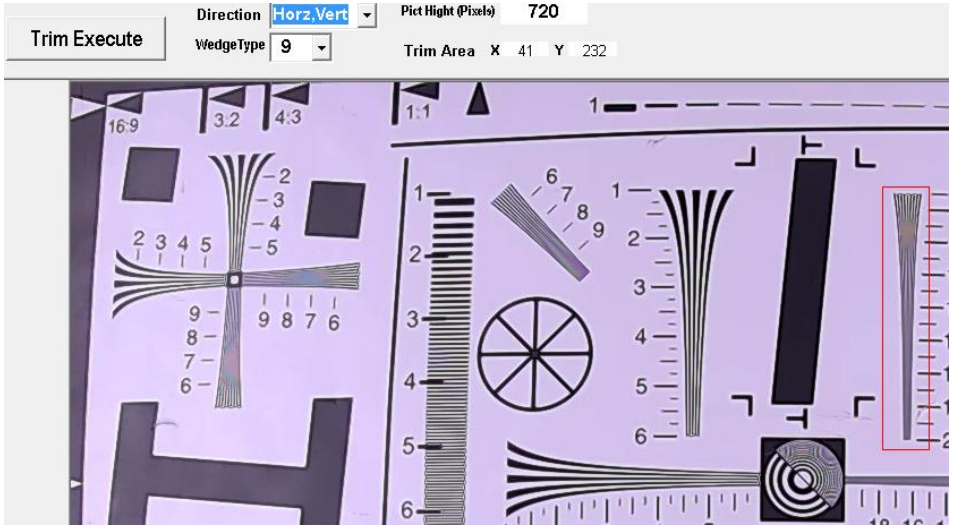
Assessing the Demosaic

- Check the resolution value by using the HYRes software. The resolution is closely related to UU.
- Check the pseudo color intensity by using the ISO12233 chart.
- Observe jaggies especially on the long and straight edges that are not horizontal and vertical. The jaggies are closely related to UA and UU.
- **U8UuSlope** significantly affects the definition and resolution. Observe the visual testing chart and balance the definition, white edge, and pseudo color.
- As all parameters affect the details, observe the distant leaves and then fine-tune parameters.
- Observe the noises under low illumination.



HYRes

- Enter the trim mode, and load a file.
- Configure **WedgeType** based on the number of TVLs. For example, set **WedgeType** to **5** for the left wedge with 100−600 TVLs, and set **WedgeType** to **9** for the right wedge with 600−2000 TVLs. In the figure, the values 1−6 indicate 100−600 TVLs, and the values 6−20 indicate 600−2000 TVLs.
- Draw a rectangle to select a wedge, and click **Trim Execute**.
- On the displayed page, click **Execute** to obtain the number of TVLs.



g_stIspAgcTable

- The 16 values of each array in the data structure correspond to the parameters values when the ISO values are 100, 200, 400, 800, 1600, 3200, 6400, 12800, 25600, 51200, 102400, 204800, 409600, 819200, 1638400, and 3276800 respectively. The ISP selects the interpolation based on the actual ISO value.

  ISO = again x dgain x isp_dgain x 100

  A larger ISO value indicates larger noises.
- Use the following values for the **demosaic_np_offset** and **ge_strength** arrays:

  //demosaic_np_offset

  {0x0, 0xa, 0x12, 0x1a, 0x20, 0x28, 0x30, 0x30, 0x30, 0x30, 0x30, 0x30, 0x30, 0x30, 0x30, 0x30},

  //ge_strength

  {0x55, 0x55, 0x55, 0x55, 0x55, 0x55, 0x37, 0x37, 0x37, 0x37, 0x37, 0x37, 0x37, 0x37, 0x37, 0x37}

Sharpen

- The demosaic module has the **SharpenAltD** and **SharpenAltUd** parameters.
- An independent SharpenRGB module is provided.
- The 3DNR module supports the image enhancement (IE) sharpen function.

A complicated scenario should contain the regions with rich texture details, flat regions with textures, and regions with obvious edges. You are advised to take pictures of distant leaves and lawns or complicated indoor articles (including fine hairs) such as the right figure.

Sharpen

- **SharpenAltD** indicates the sharpness of the large edge. Ensure that there are no blinking white spots and white edges during adjustment.
- **SharpenAltUd** indicates the detail definition of the flat region, which causes noises.
- Adjust **SharpenAltD** and **SharpenAltUd** after adjusting the demosaic module. Set them to the values as large as possible as long as there is no side effect (for example, pseudo jaggies on leaves).
- Adjust **SharpenRGB** after adjusting **SharpenAltD** and **SharpenAltUd**.
- Adjust **SharpenRGB** to a value as large as possible as long as there are no black spots and white edges.
- Adjust the preceding sharpen parameters cyclically until the values are appropriate. If the sharpen effect is not satisfied, use the IE function of the 3DNR module. The detail textures can be sharpened well by using the IE function.

Sharpen

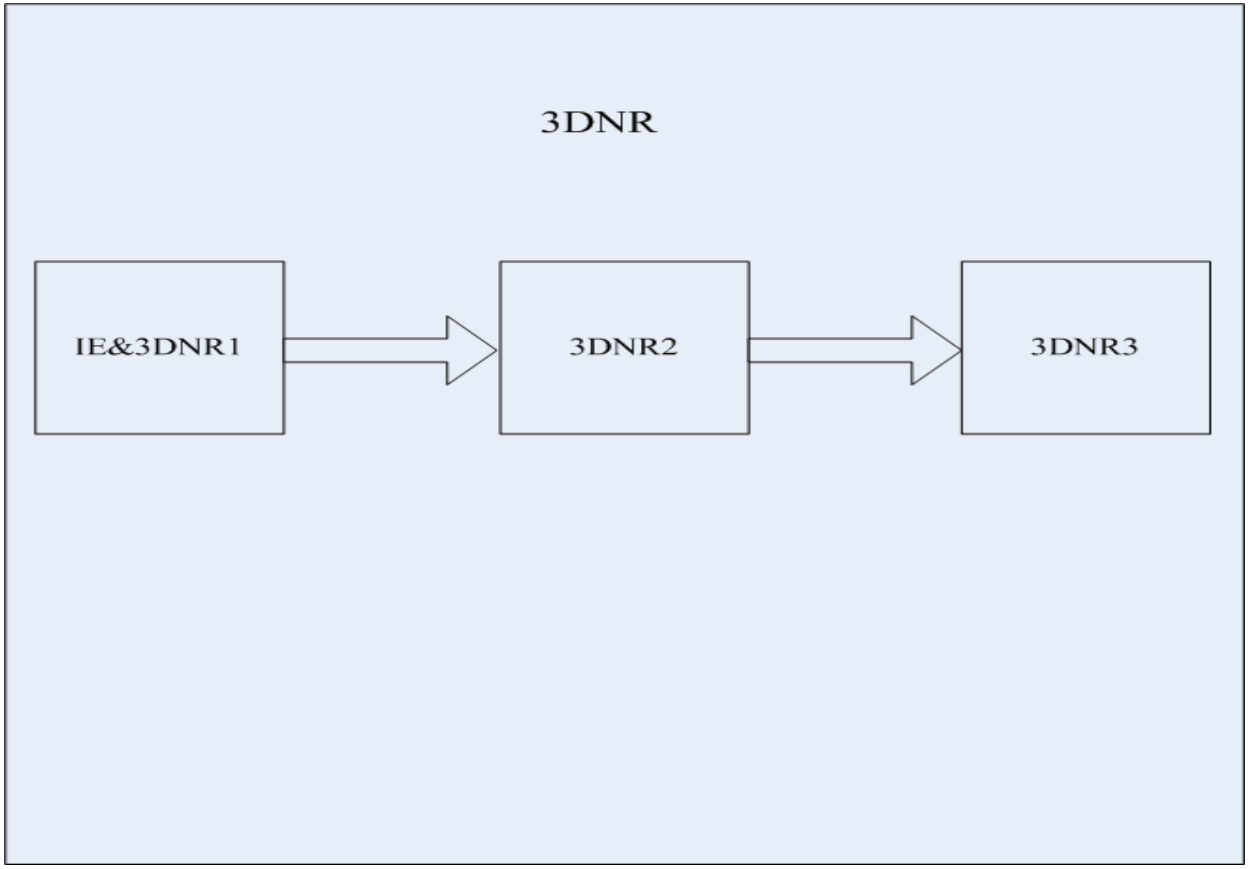
- Adjust the sharpness based on the ISO value, that is, adjust the sharpness once every 2x gain.
- Adjust the related parameters by using the sharpen function of the HiSilicon PQ Tools.
- Repeatedly adjust the parameters to balance the definition, white edges, and noises until the effect is satisfied. You are advised to stop adjustment when white edges just appear.
- Refer to the definition in the outdoor distant scenario.

Saturation Association

- More chrominance noises are caused if the saturation is too high when the gain is large.
- Record videos when sharpen parameters are adjusted.
- Adjust the ISO value.
- Balance the chrominance noise and color by adjusting parameters.

3DNR

As shown in the right figure, the software architecture of the 3DNR module is encapsulated as three layers. At layer 1, **s32GlobalStrength** can be directly configured and is automatically mapped as the parameters of layer 2, and other 3DNR parameters are set to **−1**. If the other parameters of layer 1 are modified, the parameters of layer 2 that are mapped from **s32GlobalStrength** are overwritten.



Spatial-Domain Denoising Parameters

- The **s32YSFStrength** parameter affects spatial-domain denoising.
- Spatial-domain denoising causes the article edges to become blurred. When adjusting **s32YSFStrength**, you need to balance the noises and article details.
- **S32CSFStrength** is a spatial-domain chrominance denoising parameter that can be used to suppress colorful noises.

Detail loss due to spatial-domain filtering when edges are not reserved

Time-Domain Denoising Parameters

- The **s32YTFStrength** parameter affects time-domain denoising.
- Adjusting **s32YTFStrength** significantly reduces the noises on static objects but causes smearing for moving objects.
- **s32CTFStrength** is a time-domain denoising parameter that can be used to suppress colorful noises.

Smearing caused by noise suppression when noises are obvious

Adjusting Denoising Parameters

- You are advised to adjust **s32GlobalStrength** before adjusting **s32YSFStrength**, **s32YTFStrength**, **s32CSFStrength**, and **s32CTFStrength** for the Hi3516A/Hi3516D.
- **s32YSFStrength**, **s32YTFStrength**, **s32CSFStrength**, and **s32CTFStrength** can take effect independently. Therefore, they can be adjusted separately as required.
- **S32MotionLimen** indicates the motion decree threshold. Adjusting this parameter affects the static/motion status decree for the internal algorithm as well as smearing for moving objects.

Contents

Other Adjustments

- **Automatic exposure (AE) control**
- **Lens shading correction**

  Compared with the areas around the sensor center, more lights are received in the sensor center due to the physical structure of the lens. Shading is formed in the areas around the sensor center. This is called vignetting. Some sensors have special micro lenses, which causes serious vignetting. The lens shading correction function is used to compensate and correct vigenetting.
- **Defect pixel correction**

  The values of some pixels of sensors are fixed during delivery due to process defects. These pixels are called defect pixels. During defect pixel correction, the coordinates of defect pixels are identified by using specific algorithms.
- **Wide dynamic range (WDR) sensor**
- **Encoding adjustment**

AE Control

AE parameters can be configured by calling media processing platform programming interfaces (MPIs). For details, see the *HiISP Development Reference*. The AE compensation, convergence speed, exposure tolerance, and exposure policy (highlight first or lowlight first) can be adjusted in actual indoor and outdoor scenarios.

Lens Shading Correction

Correction method

Use the ISP Calibration Tool.

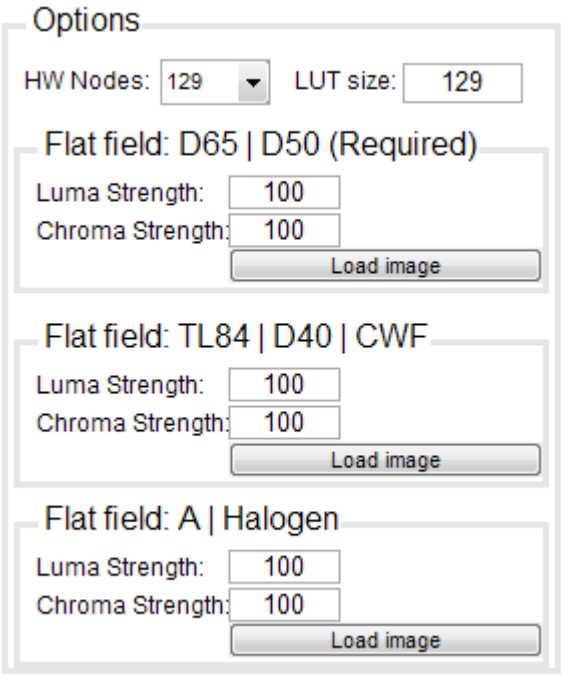
Lens Shading

- Check the lens model because lens shading is closely related to the lens model.
- The back focal length and iris size also greatly affect lens shading.
- If the surrounding environment of the sensor is dark, the areas around the image center have obvious noises. In this case, you can limit the maximum gain of the shading table or disable the shading module.

Capturing Raw Images

- Place the lens as close to the homogeneous illuminants such as the transmissive light box or viewer, ensuring the same incident lights. The luminance offset of incident lights must be less than or equal to 1%.
- Adjust **Again**, **Dgain**, and exposure time, ensuring that the luminance of the center of the captured raw image is less than or equal to 70% of the maximum luminance.
- Rename the image [*BaseName*]. **flatfield.TL84.raw**, and save it in the working directory of the ISP Calibration Tool.

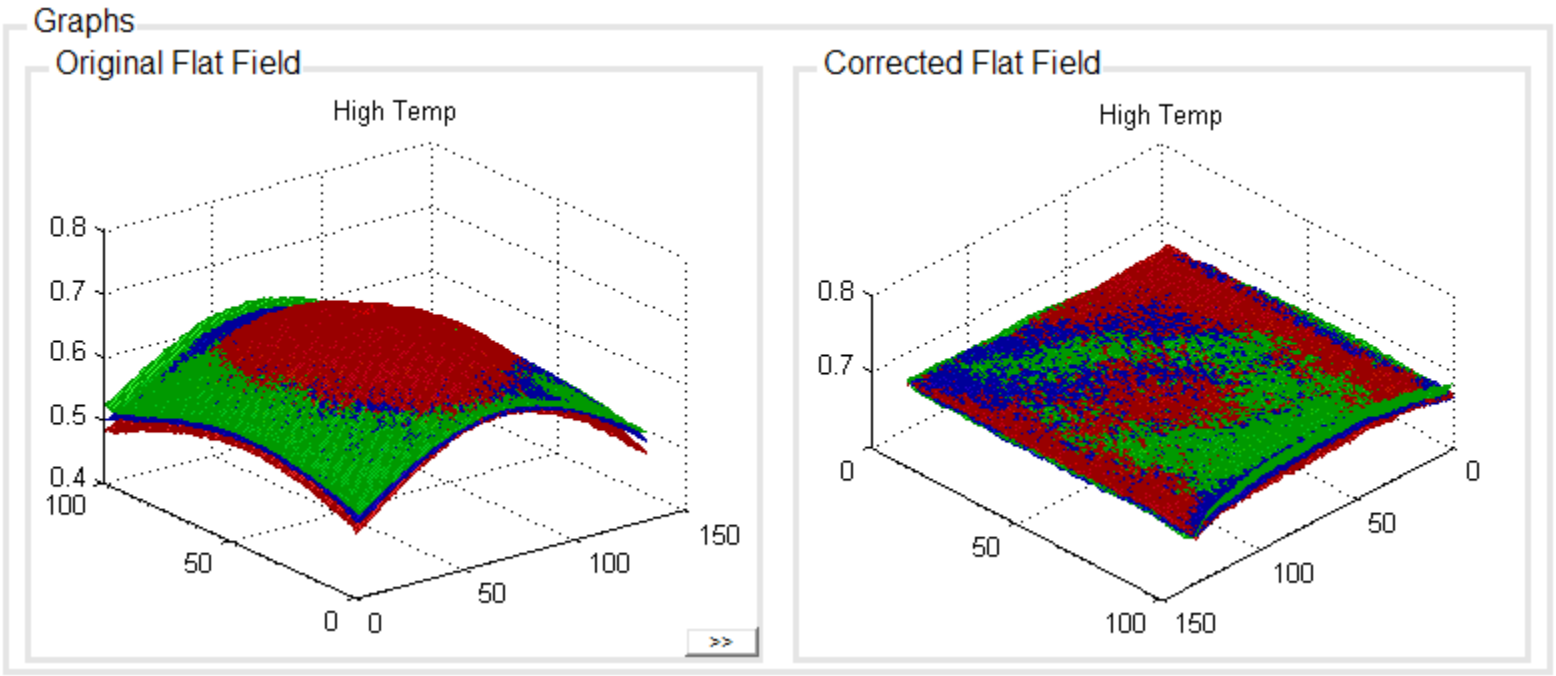
ISP Calibration



- Shading correction depends on the black level. Ensure that the black level is correctly configured.
- Click **Load Image** to load a flat field raw image. Then the shading correction table for the corresponding color temperature is generated.
- Typically, the shading table for D50 is used. If the requirements are high, you can generate shading tables for the A and TL84 illuminants and switch the shading table by using the related algorithm.

ISP Calibration

The following figures show the flat field before and after shading correction respectively:



ISP Calibration

ov5658_calibration_04-Dec-2014-17.55.40.txt

```
28  calParams.SHADING_RADIAL.high.HWnodes = 129;
29  calParams.SHADING_RADIAL.high.LUTsize = 129;
30  calParams.SHADING_RADIAL.high.rgb_centre = [1306, 836 ; 1284, 761; 1300, 797 ];
31  calParams.SHADING_RADIAL.high.off_Center = [732 690 714];
32  calParams.SHADING_RADIAL.high.rgb_shading = [1.000000, 1.002740, 1.005027, 1.00
33  1.000000, 1.001058, 1.002630, 1.004385, 1.006264, 1.008240, 1.010295, 1.012417,
34  1.000000, 1.000961, 1.002451, 1.004146, 1.005982, 1.007930, 1.009970, 1.012089,
35  ];
36  calParams.SHADING_RADIAL.medium.HWnodes = 129;
37  calParams.SHADING_RADIAL.medium.LUTsize = 129;
38  %#------ AWB Planckian parameters
```

- Search for the shading table, multiply each number by 4096, and round off the results to obtain the required table.
- To limit the maximum gain, set the luma strength to **70%−80%,** reducing the noises in corners.
- If you want to modify the table in real time and the system has high requirements on real-time data, you can reduce the shading table size. Change the number of LUT nodes, press **Enter** for the modifications to take effect, and then recalculate the results. The recommended minimum number is 33.
- If the shading table size is reduced, you can use one more node compared with the number of calibrated nodes in practice, which prevents edge exceptions. For example, if 33 nodes are calibrated, 34 nodes are used actually. The value of the extra node is the same as the value of its previous node.

Defect Pixel Correction

- If a sensor has multiple defect pixels, correct the defect pixels to increase the signal-to-noise ratio.
- Correct dark and bright defect pixels respectively.
  - ✓ After defect pixel correction, save the coordinates of the defect pixels in the flash memory. When the system starts next time, the coordinates are read from the flash memory, and HI_MPI_ISP_SetDPAttr is called to set the coordinates of defect pixels.
- Note the following during defect pixel correction:
  - ✓ Implement the cmos_set_pixel_detect() function in the **cmos.c** file.
  - ✓ Set the variables **u16CountMax** and **u16CountMin** when calling HI_MPI_ISP_SetDPCalibrate. **u16CountMax** indicates the maximum number of defect pixels, and **u16CountMin** indicates the minimum number of defect pixels. If the number of defect pixels detected by the defect pixel correction program is greater than the maximum value or less than the minimum value, defect pixel correction fails.
- For details, see the *HiISP Development Reference* and *HiISP FAQs*.

WDR

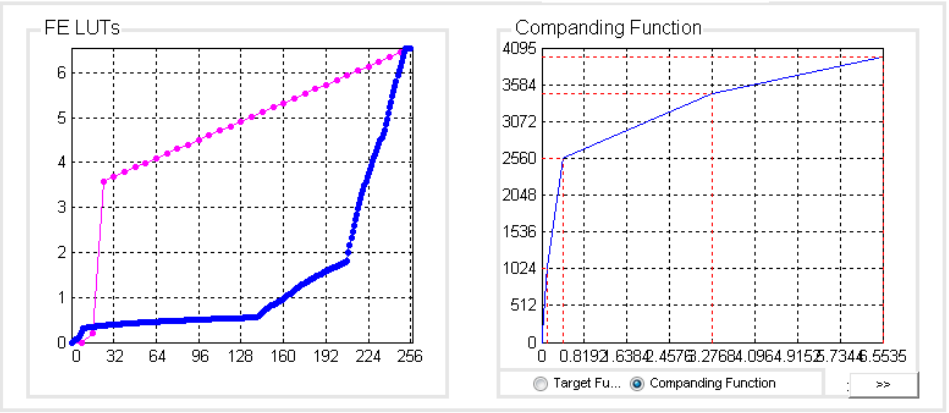
- WDR indicates that both the brightest region and the darkest region in a scenario can be viewed clearly.
- You are advised to enable WDR only when it is required.
- The WDR modes include the sensor built-in WDR mode and frame combination WDR mode.

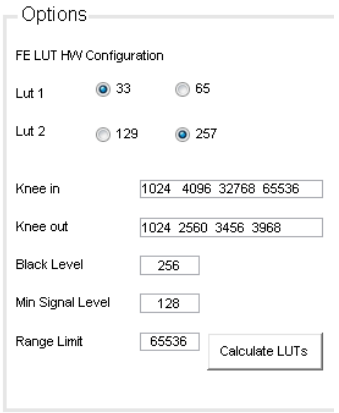
Sensor Built-in WDR

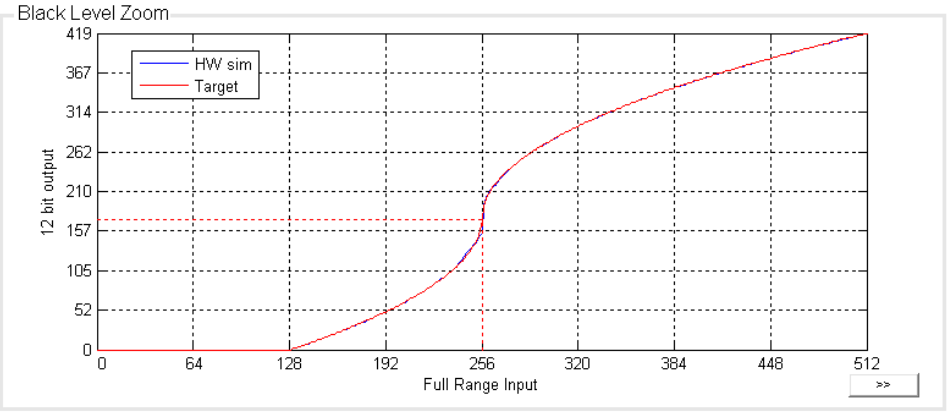
The correction parameters are different in sensor WDR mode and linear mode. The following parameters need to be recorrected:

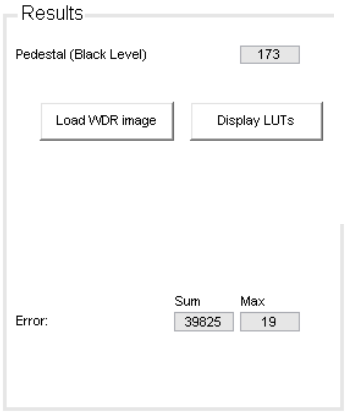
- Black level. Capture black frames, calibrate them by using the linear black level correction method, and enter the result on the **GammaFE Calibration** page to generate a dedicated WDR black level.
- **GammaFE0** and **GammaFE1**. Calibrate them by using the ISP Calibration Tool.
- Gamma. The generation method is the same as that of the WDR sensor gamma for the Hi3518.
- Noise profile
- **AE_Compensation**. Adjust it in actual outdoor and indoor scenarios.

Sensor Built-in WDR



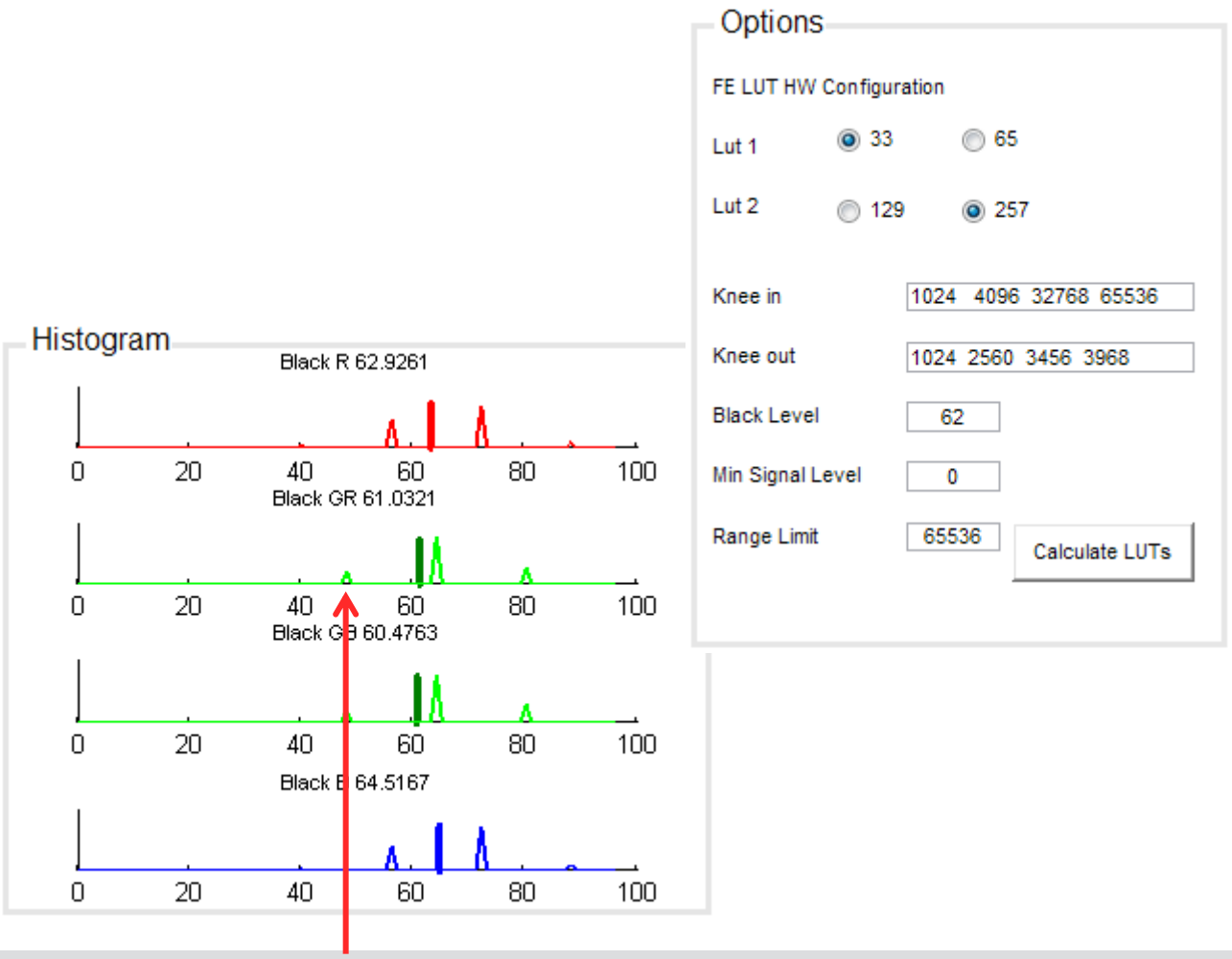






- **Lut1** is fixed at **33** and **Lut2** is fixed at **257** in **Options**.
- Enter values in **Knee in** and **Knee out** based on the compressed knee points provided in the sensor manuals.
- Enter the normal black level of the sensor in **Black Level**.
- Enter the result of **Pedestal** in **cmos.c** as the black level in built-in WDR mode.
- Save the result and export LUTs.

Sensor Built-in WDR

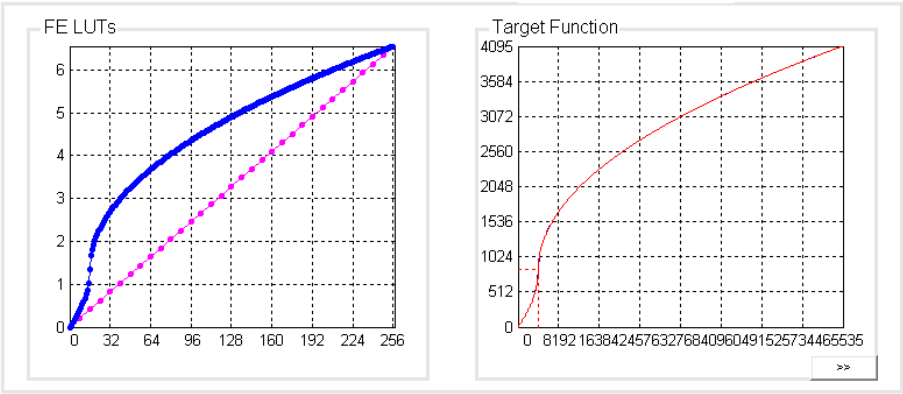


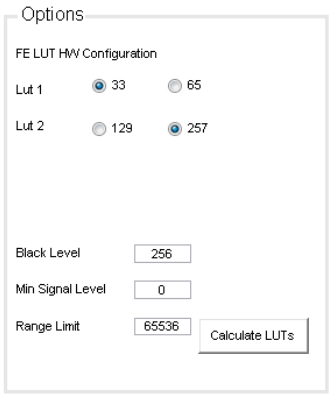
For the minimum signal level, capture the black level raw data with high gain, and obtain the minimum signal energy of each channel from the dialog box where the black level is obtained. As shown in the left figure, the minimum signal level is about 48.

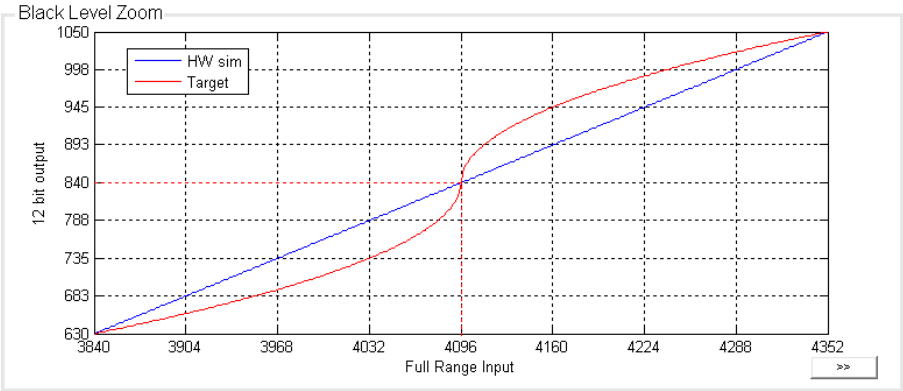
Multi-Frame Combination WDR

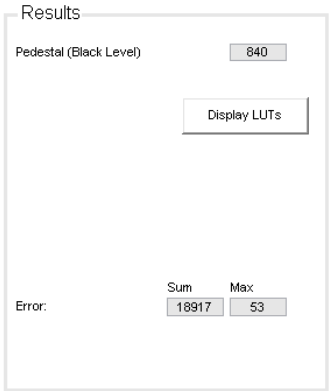
- The external sensor frames are combined by using the internal FSWDR module of the ISP.
- The **GammaFE** and gain need to take effect after the FSWDR module.
- The method of generating the black level in this mode is the same as that in linear mode.
- **GammaFE0** and **GammaFE1** of the FS-WDR in other **cmos.c** files can be directly used, because **GammaFE0** and **GammaFE1** are the same as those for the multi-frame combination WDR sensor.
- The noise profile is recorrected.
- The method of generating gamma in this mode is the same as that in built-in WDR mode.

Multi-Frame Combination WDR









- **Lut1** is fixed at **33** and **Lut2** is fixed at **257** in **Options**.
- Enter the normal black level of the sensor in **Black Level**.
- Enter **0** in **Min Signal Level**.
- Enter the result of **Pedestal** in **cmos.c** as the black level in FS-WDR mode.
- Save the result and export LUTs.

Common Issues

- **Permeability**

  The permeability is related to the definition and contrast. A higher definition indicates a higher gamma contrast and better permeability.

- **Resolution**

  The resolution is affected by demosaic parameters and sharpen parameters especially the UU slope parameter.

- **Color cast**

  For details about how to resolve the color cast issues, see the procedure for assessing the color in the "Color" section.

- **Optimization in low illumination**

  The picture quality in low illumination is affected by the luminance, definition, and noise. If the gain is limited, the maximum luminance and noises are also limited, which improves the subjective feelings. You can balance the definition and noise based on your preference. In addition, VPSS parameters need to be adjusted in low illumination to increase the 3D denoising strength. The noise profile can be adjusted to increase the denosing strength of the dark region.

Thank You