ISPTTUG

ISP Tuning Tools User Guide

Rev. 4 — 16 August 2023 User guide

Document Information

Information	Content
Keywords	Image Signal Processor, ISP Tuning Tools
Abstract	The document describes the ISP Tuning Tools designed to remotely perform image quality calibration and tuning of the Image Signal Processor (ISP) camera interface.

1 ISP Tuning tools overview

Note: *This document contains copyright material disclosed with permission of Vivante Corporation.*

The document describes the ISP Tuning Tools designed to remotely perform image quality calibration and tuning of the Image Signal Processor (ISP) camera interface.

This tool allows the user to:

- Remotely dump sensor and ISP engine registers
- Tune the sensor and ISP engine registers
- Fine-tune settings in ISP modules
- Check the results of the modified settings for captured images

This tool is designed for customers who want to fine-tune the image quality to work with the camera interface.

1.1 Component overview

The ISP Tuning Tools contain two parts: a server and a client.

Component	Description
Server	Executes on the EVK board and acts like a web server. It listens to requests from the client sent via the network and controls ISP directly.
Client	A Windows/Linux/macOS application which allows the user to tune the ISP camera interface. It sends requests to the host via an HTTP protocol and controls ISP camera interface behaviors. The client allows the user to tune registers and observe results in captured images.

1.2 Operating system compatibility

Component	System
Server	NXP Linux BSP Release LF5.15.52_2.1.0
Client	Microsoft Windows 7 x86/x64 or later

Note: *The client communicates with the server via the HTTP network protocol, so confirm that the server is ready before you use the client.*

1.3 ISP tools flow

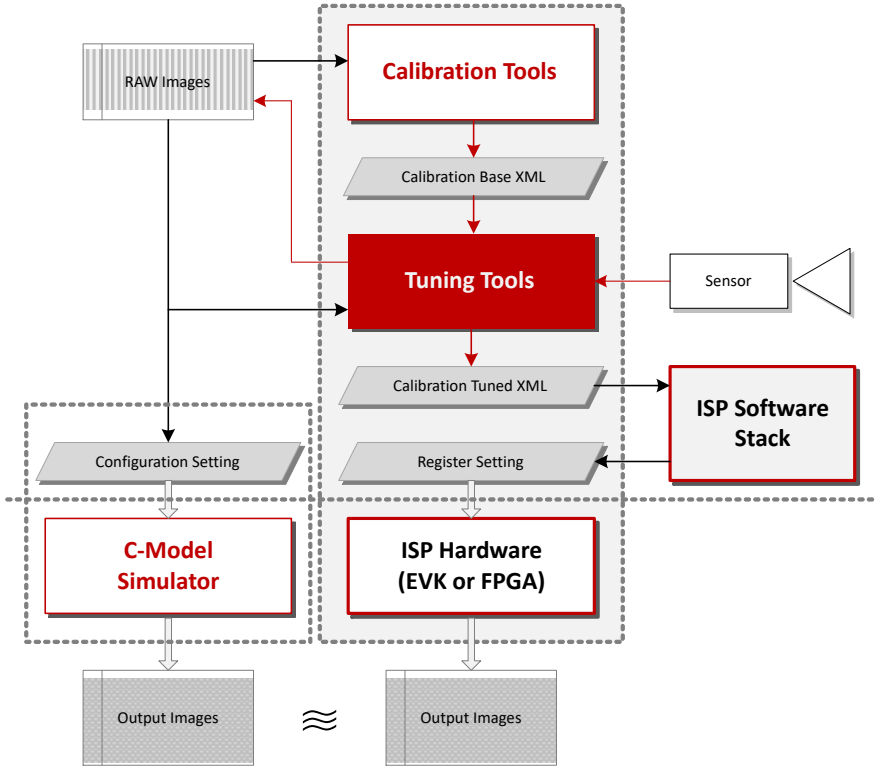

Figure 1. ISP tools flow

2 Requirements

2.1 Software requirements

- ISP Tuning Tools software release version 4.3.3.P22.1 or later

2.2 Software release package

The software release package contains the following:

- The tuning-server (running on embedded Linux).
- The tuning-client (running on Windows x86/x64) and associated files are shown in Figure 2.

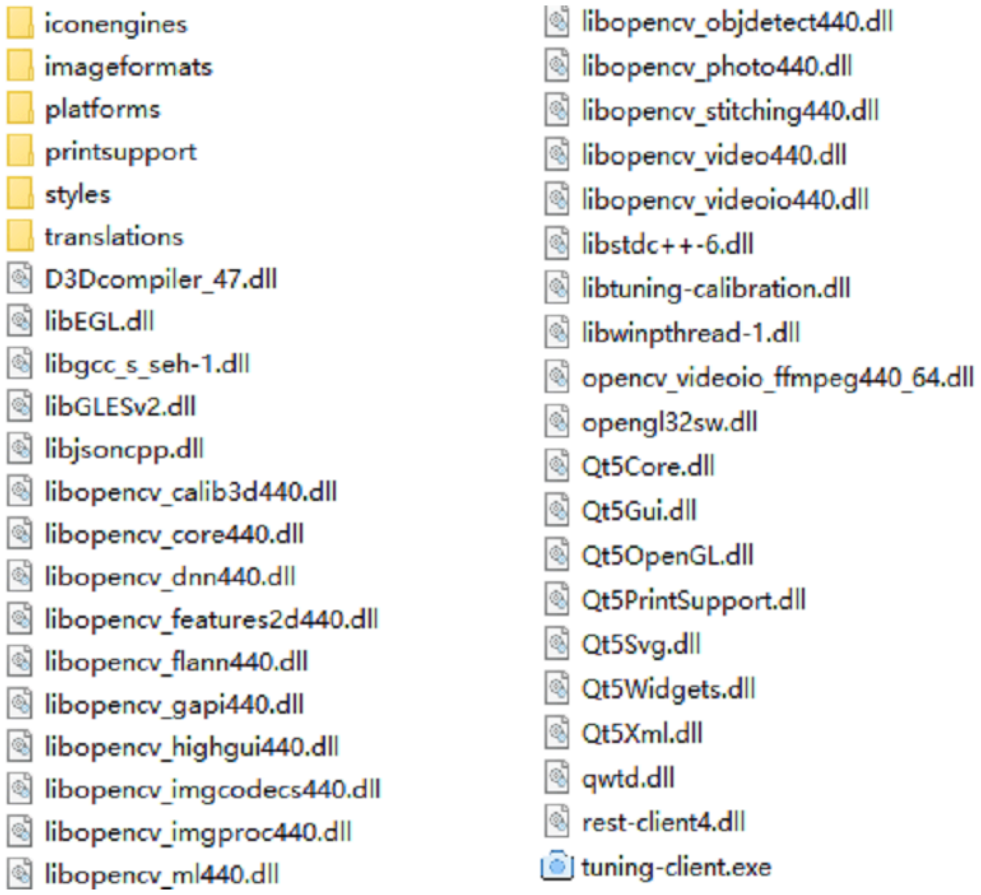

Figure 2. Example of tuning-client directory and associated files

2.2.1 Settings store location

The client supports automatic/manual adjustment of the window size similar to a macOS app. These settings are stored in the *<User Home>/.IspTuning* directory. Remove the settings folder to restore the default settings.

3 Server usage

The server runs on the EVK board via its executable program called tuning-server. The server handles requests from the client via Ethernet or Wi-Fi and directly controls the ISP behavior.

3.1 Server configuration

To set the settings on the server side, see Camera configuration. The server tool chain can either be compiled from the source or run as a binary. The installation instructions for both options are in the README file included within this entire software package deliverable.

The server default listen socket port is 8080.

To run the host, enter the following command:

```
cd /opt/imx8-isp/bin
./tuningext
```

4 Client usage

In Windows, launch ***tuning-client.exe*** to start sending requests to the target board via the network.

The basic workflow is as follows:

1. Configure the server IP in the *Edit/Preferences/Server Settings* menu.
2. Import the calibration XML file from the *File/Import All Settings/…* menu.
3. Select the sensor driver and change it in the *Input Control/Sensor Control* tab.
4. Start the preview and click the play button in the toolbar.

4.1 Main dialog

The client displays the main GUI window, as shown in Figure 3.

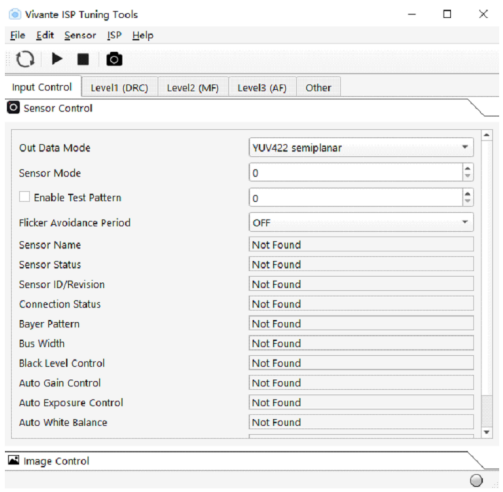

Figure 3. Main GUI

4.1.1 ISP Tuning Tools toolbar

The ISP Tuning Tools toolbar provides the following functions:

- Refresh
- Start preview
- Stop preview
- Capture image

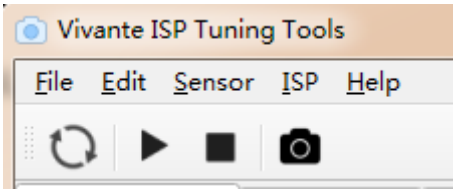

Figure 4. ISP Tuning Tools toolbar

Refresh

Click the “refresh” icon to refresh the current page information from the host end manually.

Note: The current page means that the page can be viewed right now (the top viewport of Z-order).

Start preview 

Click the “start preview” icon to open a stream preview from the server. Qt support is required on the server side.

Stop preview 

Click the “stop preview” icon to stop a stream preview from the server.

Capture 

Click the “capture” icon to capture an image from the host end and present it at the client end. The capture function works only with an active preview running.

Note: *The image presented is saved in the path configured in Save Path.*

4.1.2 Status bar

The status bar is located in the lower right corner of the main dialog and it contains the following indicators:

- **Sensor index**: indicates the current sensor
- **LED**: indicates the current page feature enable status as follows:
  - Gray: Sensor not found
  - Green: On
  - Red: Off

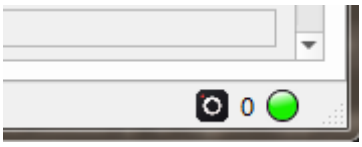

Figure 5. Status bar

4.2 File menu

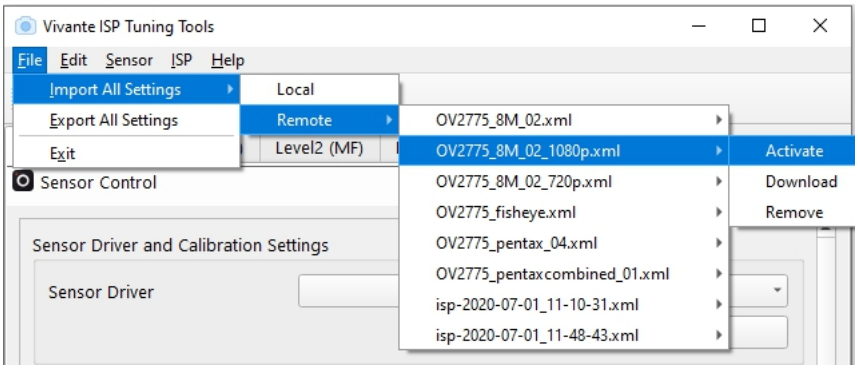

Figure 6. File menu

The “File”menu contains the following sub-menu items:

- **Import All Settings**
- **Export All Settings**
- **Exit**

4.2.1 File - Import All Settings

Import the calibration XML file to the server.

- **Local**: select the calibration XML file from the local space. This action uploads the XML file to the server.
- **Remote**: select the calibration XML file from the server.
  - Actions: the client provides the following three basic file operations:
    - Activate: make the server load the XML file.
    - Download: download the XML file from the server end to the client end.
    - Remove: remove the XML file from the server end.

Note: *The calibration XML does not contain Level1 (DRC).*

4.2.2 File - Export All Settings

Export all calibration settings to the XML file on the server and download this XML file to the client in the default location. A new location may be specified in “Preferences/Calibration Settings”. For details on the calibration settings in the XML file, see Section 5.

Note:

The calibration XML does not contain Level1 (DRC).

Note:

The calibration XML is only exported by the client end and contains both the “Sensor” and “Tuning” sections.

Note:

The “Sensor” section is generated by the calibration tools; the “Tuning” section is generated by the server end.

4.2.3 File - Exit

Exit the client application.

4.3 Edit menu preferences

Click the “Edit” Menu to bring up the “Preferences” dialog to edit user preferences.

The user preferences that may be edited in this dialog are as follows:

- **Calibration Settings**
- **Capture Settings**
- **Server Settings**
- **Windows Settings**

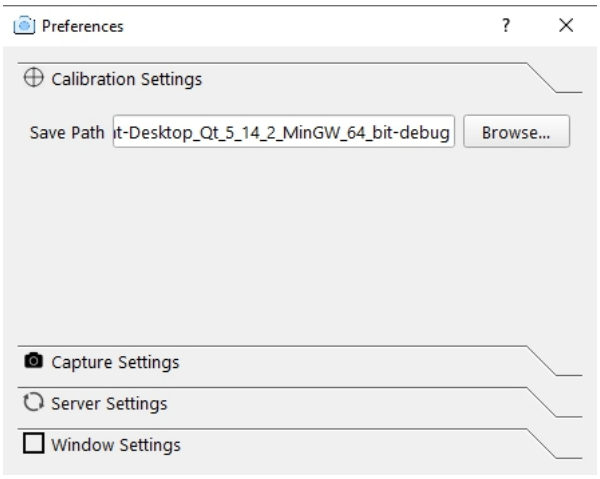

Figure 7. Preferences dialog

4.3.1 Calibration settings

Save Path: specify the location for saving the calibration XML exported from the server.

Figure 8. Calibration settings

4.3.2 Capture settings

The capture settings that may be configured are as follows:

- **Save Path**: the location of the saved images to be captured.
- **Image Type**: the image type of the captured images.
- **Lock Routine**: select between the AE, AF, or AWB lock routines.

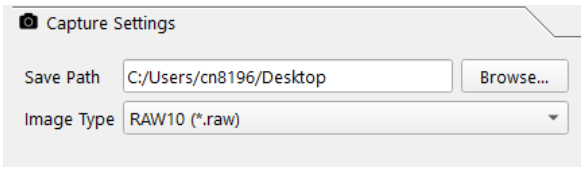

Figure 9. Capture settings

Save Path

Click “**Browse...**” to select the directory path to save the output image file.

Image Type

Select the snapshot image format from the dropdown list:

- Snapshot (YUV) saved in YUV format
- Snapshot (RAW08) saved in PGM format
- Snapshot (RAW10) saved in RAW format
- Snapshot (RAW12) saved in RAW format

Note: *When capturing raw images, the bit width of raw data must be consistent with that of the sensor mode.*

4.3.3 Server settings

Use this section to configure the server IP and port values. If the values must be changed, type in the correct values.

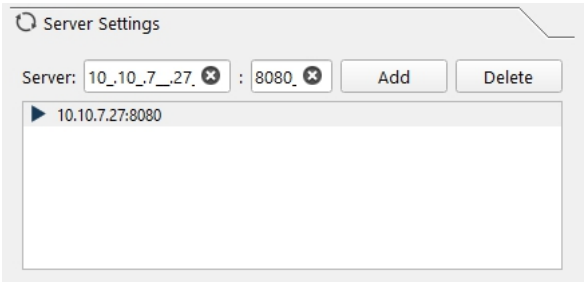

Figure 10. Server settings

Note: *The server default port is 8080. Confirm that the port does not conflict on both the server and client ends.*

4.3.4 Windows settings

Enable/disable the auto resize feature for application windows.

Figure 11. Auto resize window

4.4 Sensor menu

Use the “Sensor” menu to select which sensor to control. The “Sensor” menu list items contain the following two parts:

1. Sensor icon
2. Sensor name

The sensor icon indicates which sensor is controlled by the client.

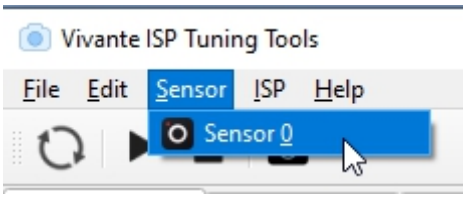

Figure 12. Sensor menu

Note: *You may see different items in this menu for your client configuration.*

4.5 ISP menu

Use the “ISP” menu to select which ISP to control. The “ISP” menu list items contain the following two parts:

1. ISP icon
2. ISP name

The ISP icon indicates which ISP is controlled by the client.

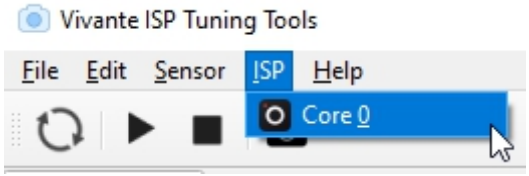

Figure 13. ISP menu

4.6 Help menu

The “Help” menu displays the client and server version numbers and dates.

4.7 ISP Tuning Tools features

The ISP Tuning Tools provides controls in the following tabs:

- Input Control Tab
- Level 1 (Driver Register Control) Tab
- Level 2 (Manual Functions) Tab
- Level 3 (Automatic Functions) Tab
- Other Tab - Dewarp Module

4.7.1 Input Control tab

The “Input Control” tab contains the following two parts:

1. **Sensor Control**
2. **Image Control** (not available for i.MX 8MP)

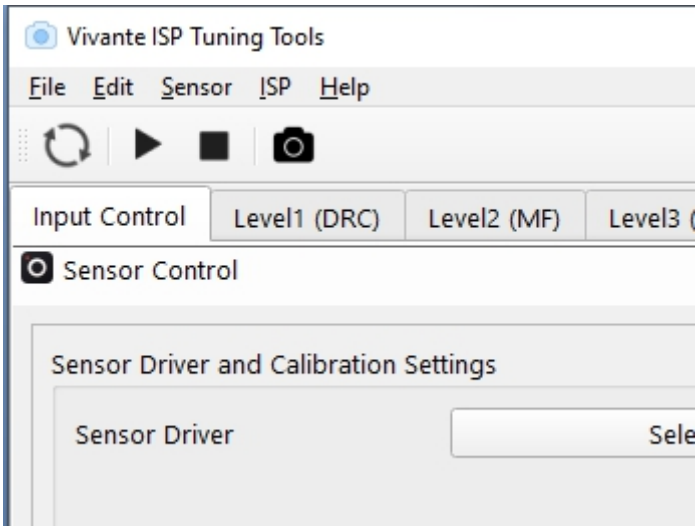

Figure 14. Input Control tab - Sensor Control

4.7.1.1 Sensor Control

The “Sensor Control” page:

- Select Sensor Mode
- Select Out Data Mode YUV422 semiplanar or interleaved
- Enables/disables the sensor test pattern
- Configures the flicker avoidance period
- Displays sensor information

Operation flow:

1. Select **Sensor Mode**, **Out Data Mode**
2. Start preview, click the "play" button in toolbar

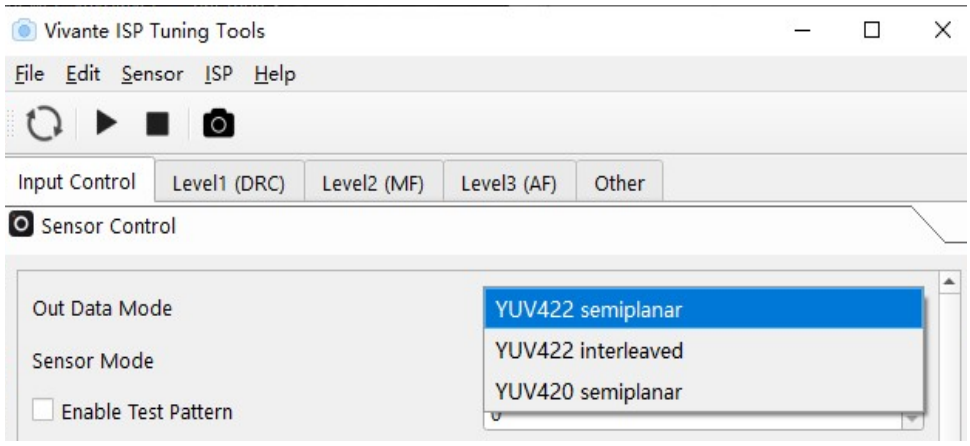

Figure 15. Out Data Mode Select

Out Data Mode

Use the **Out Data Mode** to select the output data mode (YUV422 semiplanar, YUV422 interleaved, or YUV420 semiplanar).

Sensor Mode

Use the **Sensor Mode** to select the working mode of sensor in the configuration file *Sensor0_Entry.cfg*.

Enable Test Pattern

Use the “**Enable Test Pattern”** checkbox to enable or disable the sensor test pattern.

Flicker Avoidance Period

Select the “Flicker Period” according to the supply frequency of your country (120 Hz for the USA). This avoids the flicker resulting from the camera exposure time and frequency setting.

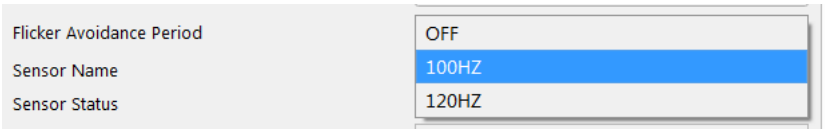

Figure 16. Flicker Avoidance Period

Sensor information

The sensor information section displays the current sensor information, such as sensor name, status, and ID.

4.7.1.2 Image control

The image and calibration settings are currently in the beta stage (not available for i.MX 8MP).

The “Image and Calibration Settings” page:

- Configures the image to use as the input of the pipeline
- Configures the load image as LSB or not LSB
- Displays image information when the image is loaded successfully

Operation flow:

- Click “**Select Image (*.pgm)”** to select the local/remote images.
- **Local**: click to upload a local image; **Remote**: hover your mouse over “**Remote”** to display the list of all images from the server and select the desired image. After selecting an image, the button displays the name of the selected image.
- Click the “**Change Image”** button to change to the selected image.
- The image information for the selected image is shown below the image selection.

Note: *The images must be captured by the client.*

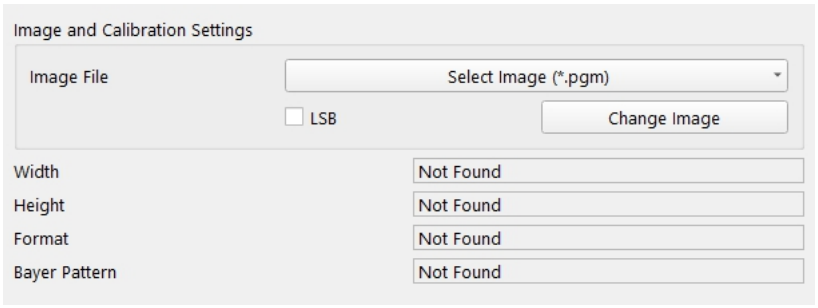

Figure 17. Image Control: Image and Calibration Settings

4.7.2 Level 1 tab - Driver Register Control (DRC)

The Level 1 (DRC) page provides the following functions:

- **Sensor Register**: direct tuning of the sensor and ISP registers
- **Calibration Data**: displays calibration data

4.7.2.1 Level 1 - Sensor Register

Note: *This module function is not available in this release. Skip this section.*

The “**Level 1 - Sensor Register”** tab enables the user to view and modify the registers of the connected sensor. An optimized register setup is defined for each sensor-lens combination during the sensor calibration and tuning process for optimized image quality.

Note: *The modification of the sensor registers should only be done by experts. Please proceed with caution with this function. Shut down and restart the application to return to the predefined default state.*

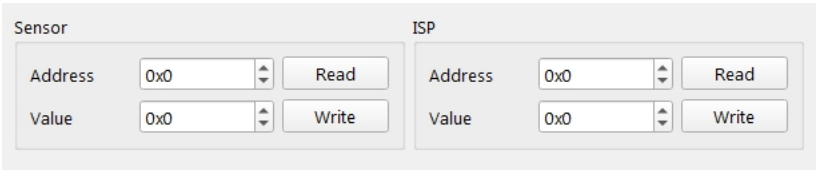

Figure 18. Sensor register dialog

4.7.2.2 Level 1 - Calibration Data

Note: *This module function is not available in this release. Skip this section.*

The "**Level 1 Calibration Data"** tab enables the user to view and modify the calibration data structure of the sensor. A set of calibration data is defined for each sensor for optimized image quality.

Note: *The modification of the calibration data should only be done by experts. Please proceed with caution with this function. Shut down and restart the application to return to the predefined default state.*

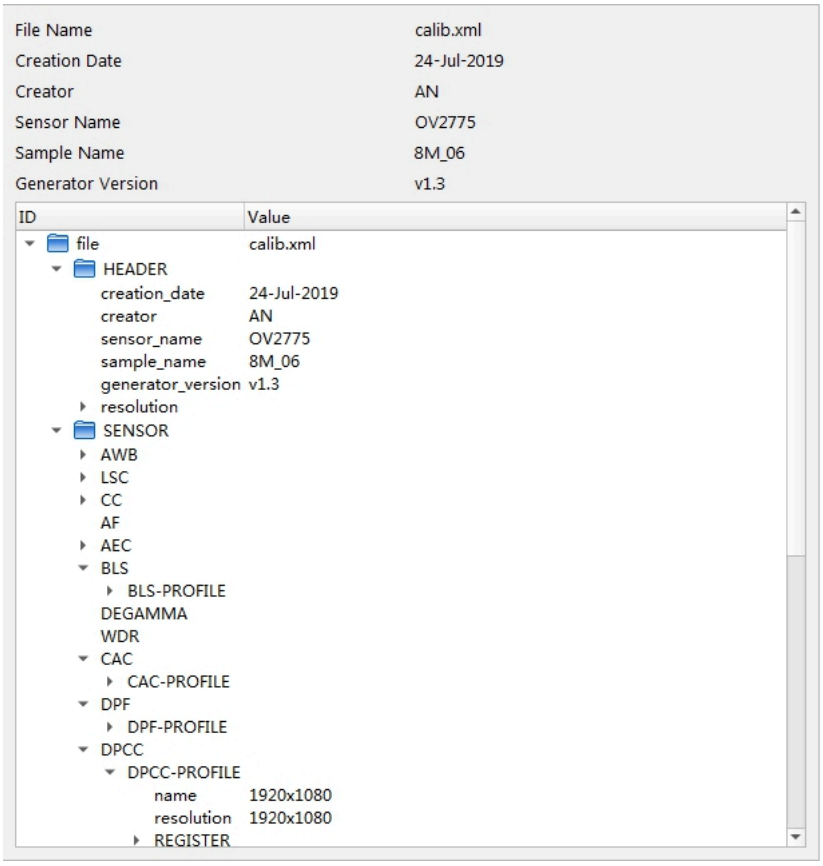

Figure 19. Calibration Data dialog

4.7.3 Level 2 Tab - Manual Functions (MF)

The **Level 2 (MF)** page enables the user to view and modify numerical and logical settings for all ISP modules on a higher level than the direct register settings.

The following settings may be modified:

- High Dynamic Range (HDR)

- Exposure Control (EC)
- Black Level Subtraction (BLS)
- Lens Shading Correction (LSC)
- White Balance (WB)
- Wide Dynamic Range 3 (WDR3)
- Defect Pixel Cluster Correction (DPCC)
- Denoising Prefilter (DPF)
- Demosaic
- Filter
- Chromatic Aberration Correction (CAC)
- Color Noise Reduction (CNR)
- Gamma Correction (GC)
- Edge Enhancement (EE) - *Note: this feature is not available for i.MX 8M Plus ISP.*
- Color Processing (CPROC)

On each page, the corresponding values can be viewed and modified. For a manual definition of most of these values, be aware that the corresponding auto-algorithms on Level 3 are switched off.

4.7.3.1 Level 2 - High Dynamic Range (HDR)

The “**HDR”** tab is used to enable/disable the HDR.

HDR is a technology that improves the range of color and contrast in a digital image. It may be used for both photographs and videos, though the implementations are different.

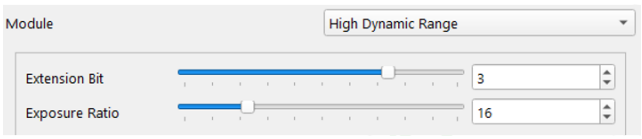

Figure 20. HDR

Extension Bit: sets the number of extended bits for a short exposure, from 0 to 4. Increasing the extension bit means a larger dynamic range.

Exposure Ratio: sets the ratio between two exposures, from 0 to 16.

4.7.3.2 Level 2 - Exposure Control (EC)

The “**EC”** tab is used to control the sensor gain and integration time if the auto exposure is disabled (Level 3).

If the auto exposure is enabled, the performance of the implemented auto exposure can be viewed.

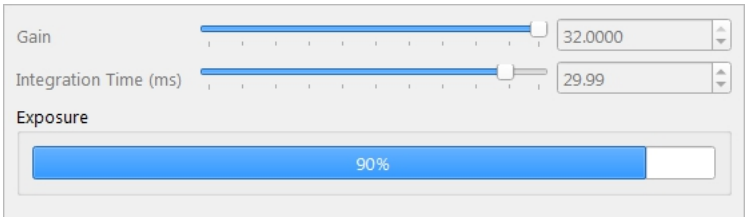

Figure 21. EC

Note: *For this demonstration system, the convergence speed of auto exposure is not optimized for low frame rates (which can occur either due to manual setting or because of low light conditions and enabled AFPS).*

There is significant headroom for acceleration of the convergence speed of the Automatic Exposure Control (AEC) software for products. To avoid flicker, the AEC controls the integration time and gain. If the AEC is disabled and the integration time is set manually, this may result in flicker. The "Exposure" slider in this dialog shows the current exposure value, but it cannot be used to manually control the exposure. If the auto exposure mode (Level 3) is disabled, this slider in this dialog can be used to control the exposure manually.

Gain: The total gain of sensor; for HDR, this is the total gain of the reference exposure.

Integration Time (ms): The integration time sensor; for HDR, this is the integration time of the reference exposure.

Exposure: The total exposure or the multiple of the total gain and integration time; for HDR, this is the exposure of the reference exposure.

4.7.3.3 Level 2 - Black Level Subtraction (BLS)

Black level offsets for the Bayer components are shown in the "**Black Level Subtraction"** dialog. The black level offsets are sensor-specific and they are the results of the sensor calibration and tuning process.

Note: *The modification of the black level offsets on this level should only be done by experts. Please proceed with caution with this function. Shut down and restart the application to return to the predefined default state.*

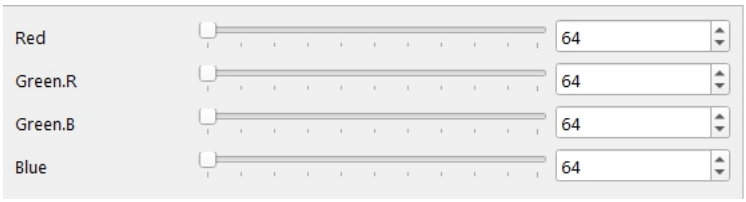

Figure 22. BLS

Red: the black level subtraction value of the red channel

Green.R: the black level subtraction value of the green_r channel

Green.B: the black level subtraction value of the green_b channel

Blue: the black level subtraction value of the blue channel

4.7.3.4 Level 2 - Lens Shading Correction (LSC)

The "**LSC"** tab is used to enable/disable the LSC.

Using shading correction, your software can remove image structures that originate in the imaging system that do not belong to the actual image information.

Without shading correction, the imaging system would cause image defects to be superimposed on the actual image information. When a shading correction is employed, these faults in the image are determined and immediately corrected in the live image.

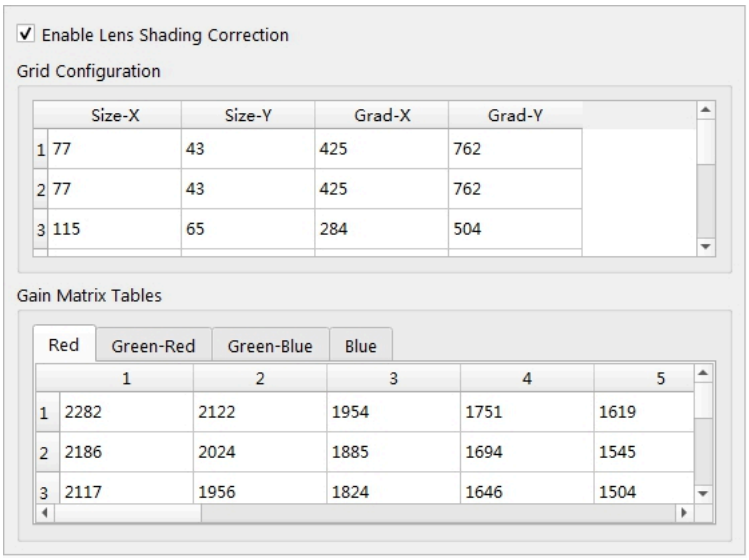

Figure 23. LSC

During the LSC, the frame is divided into 16 sectors in the x- and y-dimensions. To reduce hardware effort, the position and size of mirrored sectors related to the frame center are equivalent. For example, the size of sector x1 = x16, y3 = y14. However, the correction factors are independent for each sector.

Grid configuration:

Size-X: the size of sector_N in the x dimension.

Size-Y: the size of sector_N in the y dimension.

Grad-X: the factor for the x-gradient of sector_N.

Grad-Y: the factor for the y-gradient of sector_N.

For example: $Grad\text{-}X\text{-}N = INT(\frac{2^{15}}{Size\text{-}X\text{-}N})$

Gain Matrix Tables: the LSC correction factors; 16x16 sectors have 17x17 vertices. Red, green-red, green-blue, and blue channels each have a set of correction parameters. The correction factor is a fixed-point number, 2-bit integer with a 10-bit fractional part with range [1~3.999].

4.7.3.5 Level 2 - White Balance (WB)

The **WB** tab is used to adjust values for white balance gains for the following:

- Red
- Green.R
- Green.B
- Blue

The WB tab also configures the color correction matrix values.

White balance is the process of removing unrealistic color casts, so that objects which appear white in person are rendered white in your photograph. Proper camera white balance must consider the color temperature of a light source, which refers to the relative warmth or coolness of white light. Our eyes are very good at judging what is white under different light sources, but digital cameras often have great difficulty with Auto White Balance (AWB) and they can create unsightly blue, orange, or even green color casts. Understanding digital

white balance can help you avoid these color casts, therefore improving your photographs under a wider range of lighting conditions.

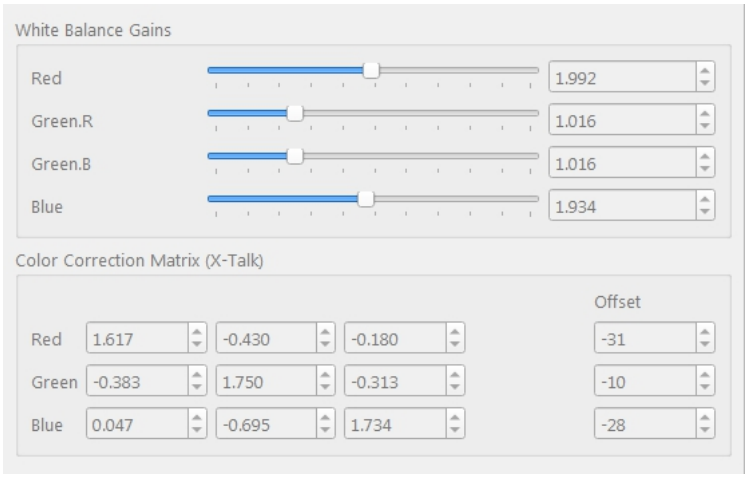

Figure 24. WB

When Auto Exposure/Automatic White Balance (AE/AWB) algorithms are running, you will observe a constant refresh of varying values. The monitored values correspond to the register settings of the ISP hardware, which are controlled by AWB.

When AWB is disabled, these sliders in this dialog may be used to manually control each channel's gain, color correction matrix, and offset. Reenabling AWB automatically readapts the demonstration system to the current illumination conditions.

4.7.3.6 Level 2 - Wide Dynamic Range 3 (WDR3)

The WDR3 tab is used to enable/disable the Wide Dynamic Range 3 (WDR3).

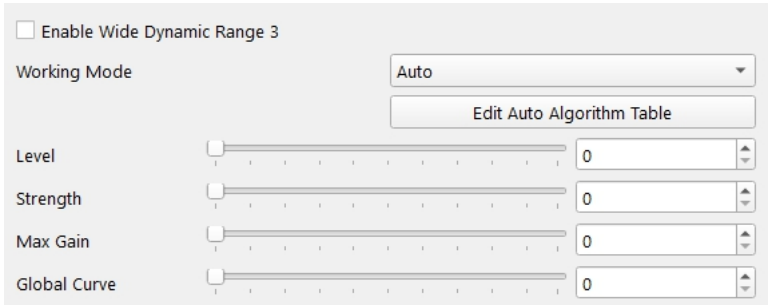

Figure 25. WDR3

WDR3 has many parameters that can be tuned. However, this dialog only provides options to update the setting of level, strength, maximum gain, and global curve. Entropy and histogram also must be tuned for some HDR issues, such as halo issues. Currently, the entropy value table in the source is used to tune the halo issues.

The main idea of the WDR3 algorithm is entropy. All local tone mapping is based on entropy. If the entropy of this region is high, the region contains a lot of information, so it must be enhanced to make it more vivid. If the entropy is low, the region is flat, so it must be retained or compressed regardless of whether it is dark or bright.

Working Mode

Auto: automatically adjusts Strength, Max Gain, and Global Curve parameter according to the Level and Auto Algorithm Table

- **Edit Auto Algorithm Table**: generate a data table for driver automatic adjustments
- **Level:** set the level of automatic adjustments

Manual: disable the automatic adjustment feature; manually adjusts Strength, Max Gain, and Global Curve parameter

Edit Auto Algorithm Table actions:

- Request table template or built-in data table from the server
- Display a table in a pop-up
- Edit a table with the UI, user can add/delete rows
- Confirm a new data table, send a data table back to the server

The WDR tuning parameters are described below:

Strength: dynamic range is [0, 128], default value is 100

Max Gain: dynamic range is [0, 128], default value is 16

Global Curve: dynamic range is [0, 128], default value is 64

The goal of this tuning is to adjust the WDR3 strength according to the sensor analog gain. In general, only one parameter must be changed in the frame interval of the camera preview. The equation is shown below:

wdr3_strength = MIN (128, MAX (0, 128- sensor_analog_gain * 8));

Here, the WDR3 is fully enabled when the illumination is very good (sensor analog gain is small), such as outdoors or a bright room. The WDR3 is decreased when the illumination is dark (sensor analog gain is high). The WDR3 dynamic range is [0, 128].

The WDR3 provides a parameter to limit the maximum enhancement level:

wdr3_max_gain = 16;

All internal enhancements are limited by this parameter. Its dynamic range is [0, 128].

In addition, the WDR3 provides a parameter to adjust the image global contrast:

wdr3_global_strength = 64;

The image contrast is adjusted according to this parameter. Its dynamic range is [0, 128].

4.7.3.7 Level 2 - Defect Pixel Cluster Correction (DPCC)

The **DPCC** tab is used to enable/disable the DPCC.

Defective pixels and pixel clusters can be corrected on-the-fly when the DPCC module is enabled. Check the "**Enable Defect Pixel Cluster Correction"** checkbox in this dialog to enable the DPCC.

Note: *The DPCC settings are currently not adapted to image statistics; only static presets are implemented.*

Note: *For better demonstration of the on-the-fly algorithm, the defect pixel correction table which collects the static position information of defect pixel is not used (currently available in hardware only).*

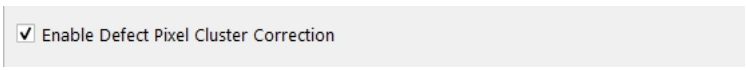

Figure 26. DPCC

4.7.3.8 Level 2 - Denoising Prefilter (DPF)

The DPF tab is used to enable/disable the DPF.

If the DPF is disabled, the DPF tab allows you to tune the DPF module configuration.

In low light situations or high gains, the denoising prefilter helps to reduce the noise in the resulting image.

Note: *The DPF settings are currently not fully adapted to image statistics; only a simple gain adaptive setting is implemented.*

Note: *The modification of the DPF values should only be done by experts. Please proceed with caution with this function. Shut down and restart the application to return to the predefined default state.*

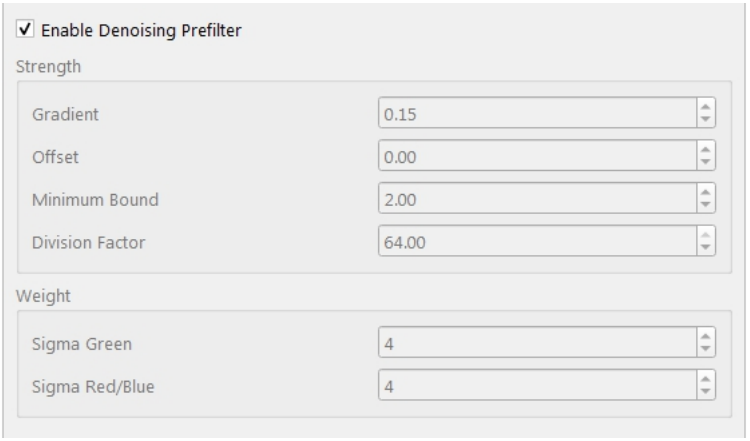

Figure 27. DPF

The “Strength” parameters are used to calculate the denoise strength.

Gradient

Offset

Minimum Bound

Division Factor

Where:

fStrength = sqrtf(Gradient * fSensorGain) + offset;

fStrength = MIN(Minimum_Bound, fStrength)

InvStrength = INT(Division_Factor / fStrength)

Note: *InvStrength is the filter strength weight of the red/green/blue filter.*

The following are the “Weight” parameters:

Sigma Green: the spatial filter’s sigma of the green channel

Sigma Red/Blue: the spatial filter’s sigma of the red/blue channel

SWeight = exp(-1.0 * spatialRadius / (2*sigma_C*sigma_C))

where: C = green/red/ blue

4.7.3.9 Level 2 - Demosaic

The **Demosaic** tab is used to enable/disable the “Demosaicing” and it sets the texture-detection threshold.

Figure 28. Demosaic

Texture Detection Threshold: the threshold for Bayer demosaicing texture detection with the range of [0..255].

Where:

0: maximum edge sensitivity

255: no texture detection

4.7.3.10 Level 2 - Filter

The “Filter” tab is used to enable/disable the filter and adjust the denoising and sharpening filtering values.

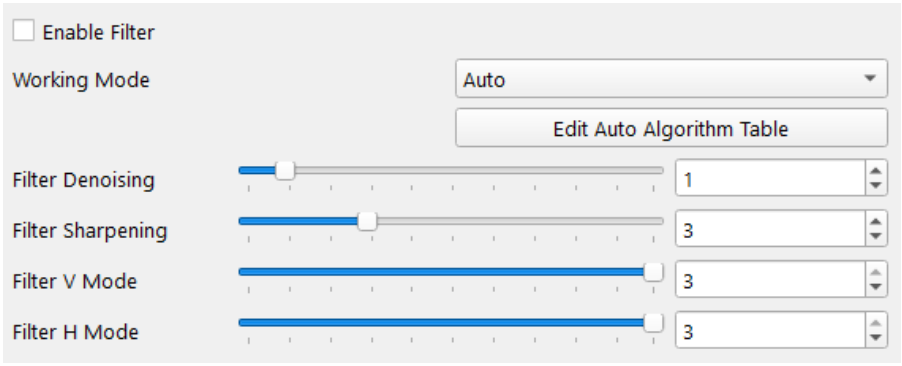

Figure 29. Filter

Working Mode

Auto: enables automatic adjustment feature; automatically adjusts Filter Denoising and Sharpening value

- **Edit Auto Algorithm Table:** generate a data table for driver automatic adjustments
- **Level:** set the level of automatic adjustments

Manual: disable the automatic adjustment feature

Edit Auto Algorithm Table actions:

- Request the table template or built-in data table from the server
- Display the table in a pop-up
- Edit the table with the UI, user can add/delete rows
- Confirm a new data table, send the data table back to the server

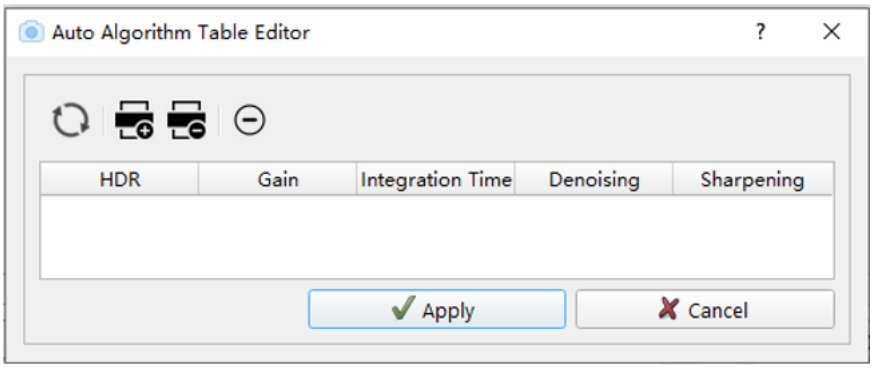

Figure 30. Auto Algorithm Table

- **HDR:** enable or disable HDR
- **Gain:** set gain date
- **Integration Time:** set integration time data
- **Denoising:** set denoising data
- **Sharpening:** set sharpening data

Parameters:

- **Filter Denoising:** controls the denoise level (from 0 to 10)
- **Filter Sharpening:** controls the sharpening level (from 0 to 10)
- **Filter V Mode:** Chroma filter vertical mode (from 0 to 3)
- **Filter H Mode:** Chroma filter horizontal mode (from 0 to 3)
- **Filter V Mode:** Chroma filter vertical mode (from 0 to 3)
- **Filter H Mode:** Chroma filter horizontal mode (from 0 to 3)

4.7.3.11 Level 2 - Chromatic Aberration Correction (CAC)

The “**CAC”** tab is used to enable/disable the CAC.

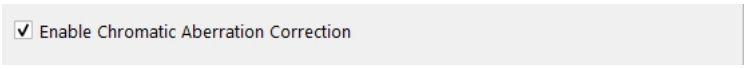

Figure 31. CAC

4.7.3.12 Level 2 - Color Noise Reduction (CNR)

The “**CNR”** tab is used to enable/disable the CNR and set threshold values for color channels 1 and 2.

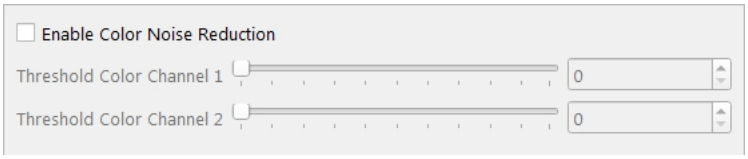

Figure 32. CNR

Threshold Color Channel 1: the color noise removal threshold value of the Cb channel

Threshold Color Channel 2: the color noise removal threshold value of the Cr channel

The larger the value, the stronger the noise reduction.

4.7.3.13 Level 2 - Gamma Correction (GC)

The “**GC”** tab is used to enable/disable GC.

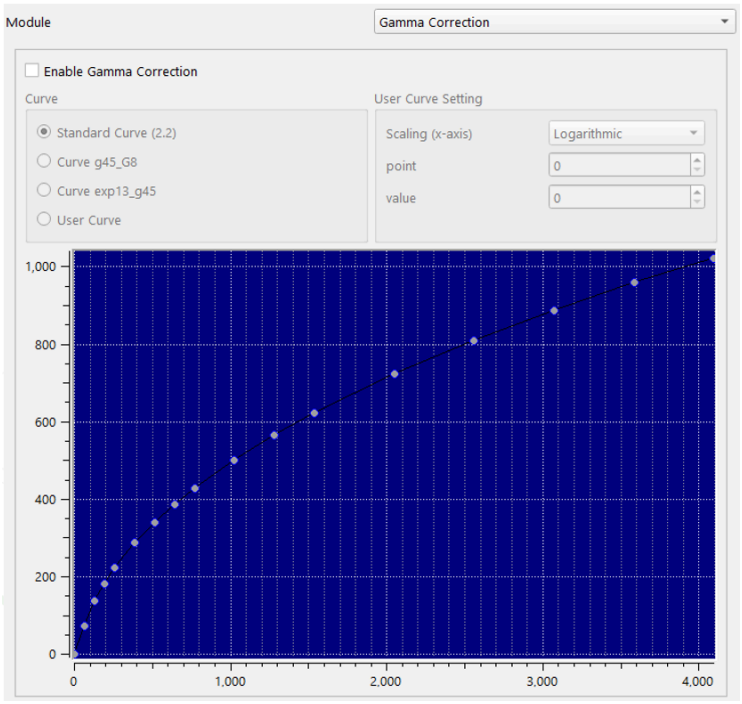

Figure 33. GC

A list of Gamma Correction curves is shown. When one of the curves is selected, it is displayed on the interface.

User Curve Setting: used to customize the curve for different gamma values

Scaling (x-axis): selects the gamma segmentation mode: Logarithmic and Segmentation

Logarithmic: logarithmic segmentation from 0 to 4095, (64,64,64,64,128,128,128,128,256,256,256,512, 512,512,512,512)

Segmentation: equidistant segmentation from 0 to 4095, (256, 256, ...); all 16 segments are 256

point, value: sets the gamma user curve point and corresponding value

4.7.3.14 Level 2 - Color Processing (CPROC)

The “**CPROC”** tab is used to enable/disable CPROC and set color-processing values for contrast, brightness, saturation, and hue.

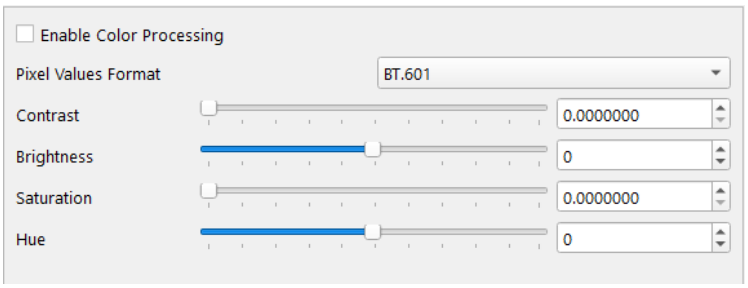

Figure 34. CPROC

Pixel Values Format: selects an output format: full range or limited range (BT.601)

Contrast: sets contrast: default=1, Greater than 1, Increases contrast; Less than 1, Decreases contrast

Brightness: sets brightness: default=0, Greater than 0, Increases brightness; Less than 0, Decreases brightness

Saturation: sets saturation: default=1, Greater than 1, Increases saturation; Less than 1, Decreases saturation

Hue: sets hue: default=0, Greater than 0, Increases hue; Less than 0, Decreases hue

4.7.4 Level 3 Tab - Automatic Functions (AF)

The AF allows the user to view and modify the camera engine functions:

- Automatic Exposure (AE)
- Automatic Focus (AF)
- Automatic White Balance (AWB)

Note: *The convergence speed of the automatic functions depends on the current frame rate.*

4.7.4.1 Level 3 - Automatic Exposure Control (AE)

The "**AE**" tab automatically controls the sensor's analog gain and integration time to achieve a well-exposed image. Auto-exposure can be started and stopped using the checkbox at the top of the dialog.

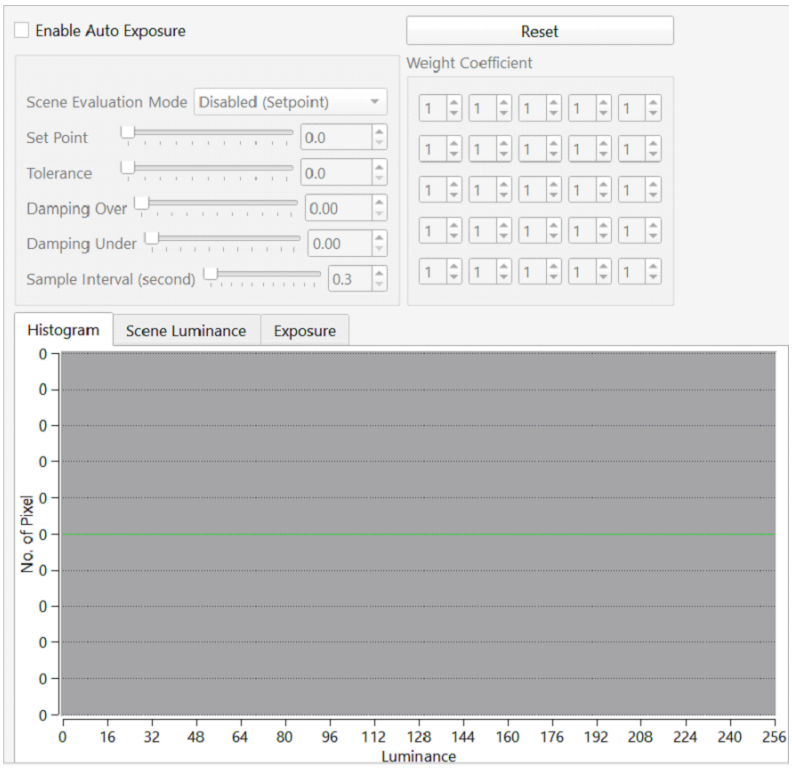

Figure 35. Automatic Exposure (AE)

The following scene evaluation modes can be selected in the drop-down menu:

- **Disabled**: AE is controlled by the set point. Besides the set point, other scene-evaluation modes are not supported.
- **Fix**: A static Region Of Interest (ROI) is used for exposure adjustment.
- **Adaptive**: A ROI is adaptively selected for exposure adjustment.

The AE must be stopped to change the scene evaluation mode.

- **Set Point:** target value of auto exposure control.
- **Tolerance**: the tolerance of brightness changes; when brightness changes > tolerance, adjust the exposure value. The tolerance change is as follows: $\frac{|m_0 - m_{meas}|}{m_0} > tolerance$
- **Damping Over:** the damping factor, used to smooth the exposure value of the front and back frames. when the measure value > Set_Point, use Damping Over.
- **Damping Under:** when the measure value <= Set_Point, use Damping Under. *Note: Damping Over <= Damping Under.*
- **Sample interval (second):** statistics to show the refresh rate.
- **Weight Coefficient:** the weight coefficients of regions. This weight is the weight coefficient of 25 sub-windows of AE, which is involved in calculating the target brightness value. Increasing the weight of regions that are “brighter than the target” decreases the overall image brightness; increasing the weight of regions that are “below the target brightness” increases the overall image brightness. The range is [1, 16] of integer type, 1 is the minimum weight, 16 is the maximum weight.

For the AE measurements, the “Scene Luminance”, “Histogram”, and “Exposure” tabs provide an overview on the derived scene statistics.

Scene Luminance provides the mean luminance measured in the respective image rectangle. If “Adaptive Scene Evaluation” is enabled, the foreground and background can be distinguished by different text colors.

Histogram shows the current image histogram.

Exposure shows the gain (red) and integration time (green) over time.

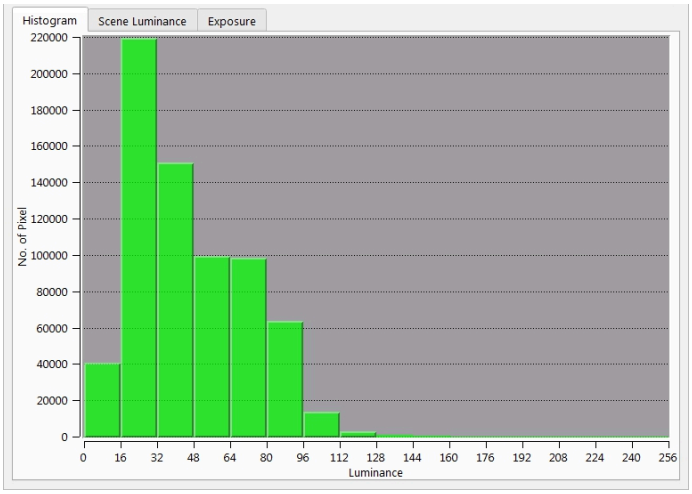

Figure 36. AE dialog with histogram

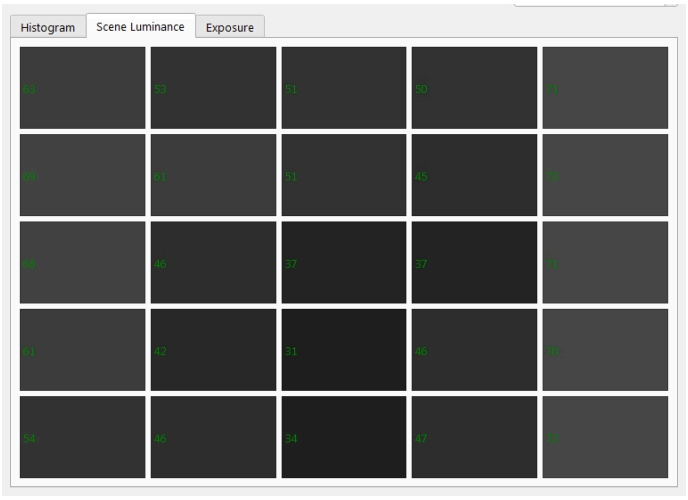

Figure 37. AE dialog with scene luminance

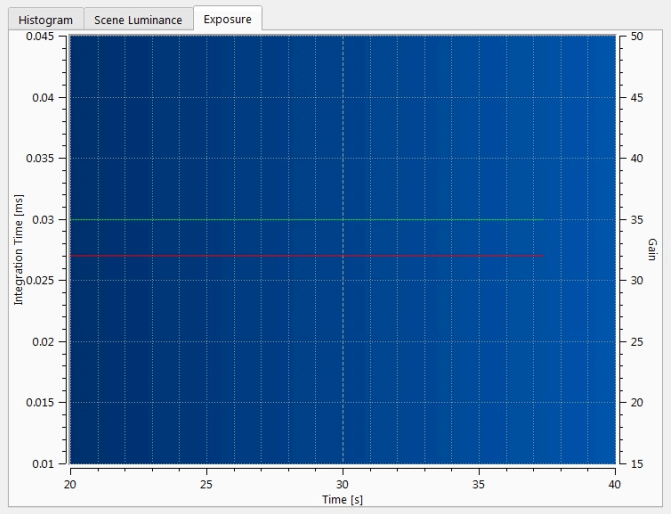

Figure 38. AE dialog with exposure measurements

4.7.4.2 Level 3 - Automatic Focus control (AF)

The “**AF”** tab is used to enable/disable the automatic focus if the sensor supports automatic focus.

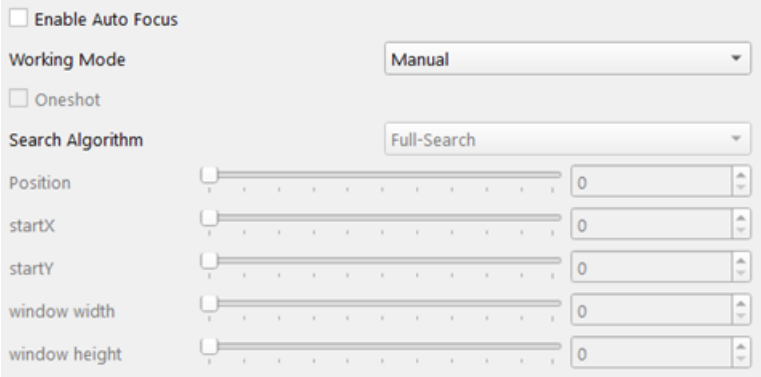

Figure 39. Automatic Focus Control (AF)

- **Enable Auto Focus** checkbox: enables/disables auto focus
- **Working Mode:** selects the working mode between auto or manual
- **Oneshot checkbox:** selects one-shot mode to run auto focus once
- **Search Algorithm:** selects the Automatic Focus search algorithm
- **Position:** focal length
- **startX:** the horizontal starting position of the focal area
- **startY:** the vertical starting position of the focal area
- **window width:** the width of the focal area
- **window height:** the height of the focal area

4.7.4.3 Level 3 - Automatic White Balance control (AWB)

The “**AWB”** tab is used to automatically control the digital gain and color correction of the ISP. It also adapts the lens shading and the color saturation with respect to the selected or detected illumination.

If the AWB is stopped, it can be switched into the manual mode to select a certain illumination profile from the drop-down menu.

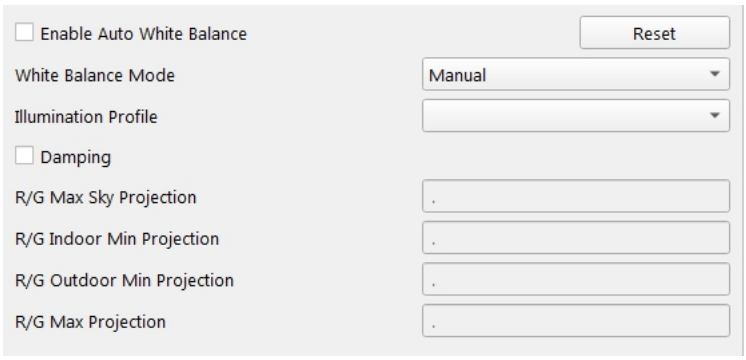

Figure 40. AWB

Enable Auto White Balance checkbox: enables/disables the AWB.

White Balance Mode: selects the white balance mode.

Illumination Profile: selects the illumination profile.

Damping checkbox: changes the white balance smoothly through temporal damping.

R/G Max Sky Projection: AWB gain clipping: the projection point of the maximum sky threshold. Defines the upper boundary for the threshold polygon used for adjusting the reproduction of blue-sky scenes. If the AWB measurement value is above this value, then the AWB does not adjust the gains anymore, so that the settings from previous frames are used.

R/G Indoor Min Projection: AWB gain clipping: the projection point of the minimum indoor threshold. Defines the minimum red divided by green gain for indoor light sources for the projection polygon.

R/G Outdoor Min Projection: AWB gain clipping: the projection point of the minimum outdoor threshold. Defines the minimum red divided by green gain for outdoor conditions for the projection polygon.

R/G Max Projection: AWB gain clipping: the projection point of the maximum threshold. Defines the upper boundary for the projection polygon. This is the limit for the white balance correction of high color temperatures.

4.7.5 Other tab - Dewarp module

The "**Dewarp**" functions enable the user to:

- Bypass dewarp
- Enable/disable HFlip
- Enable/disable VFlip
- Switch dewarp mode (distortion correction, fisheye expand, fisheye dewarp)
- Adjust dewarp matrix

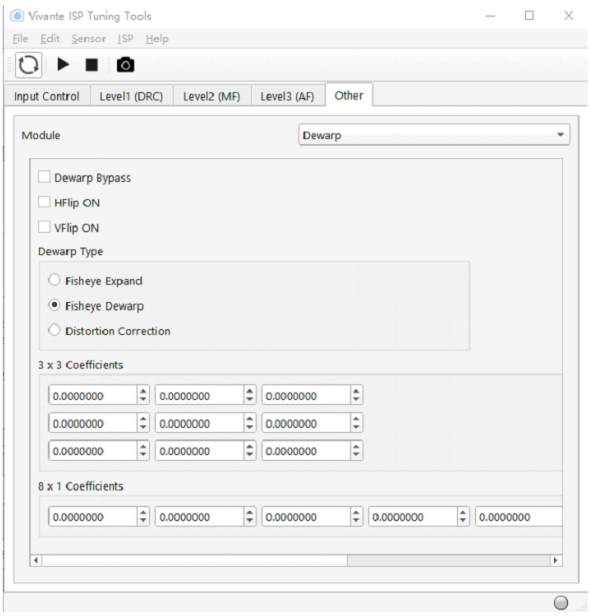

Figure 41. Dewarp

- **Dewarp Bypass:** bypasses the dewarp module
- **HFlip ON:** enables the horizontal flip function
- **VFlip ON:** enables the vertical flip function

Dewarp Type: selects the dewarp mode:

- **Fisheye Expand**
- **Fisheye Dewarp**
- **Distortion Correction**

3 x 3 Coefficients: camera matrix parameters

8 x 1 Coefficients: distortion matrix parameters

4.7.5.1 Dewarp - Calibration

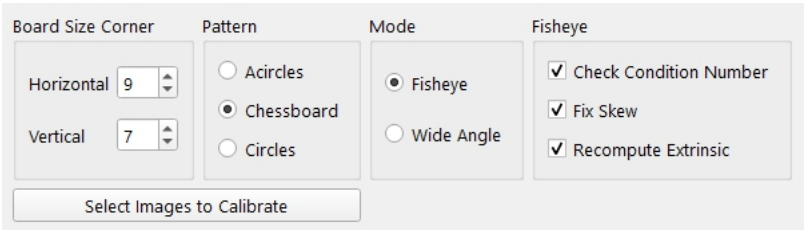

Figure 42. Dewarp - Calibration: Fisheye mode

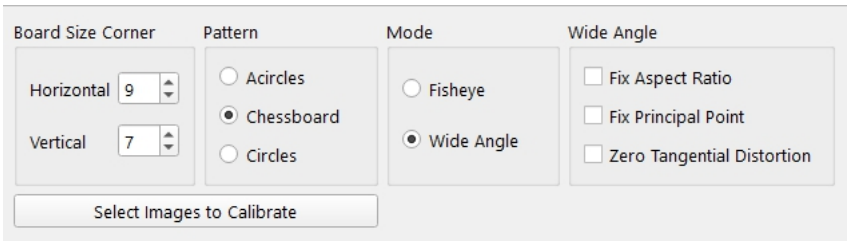

Figure 43. Dewarp - Calibration: Wide Angle mode

Board Size Corner: horizontal and vertical corner count.

Pattern: select the pattern: “Acircles”, “Chessboard”, or “Circles”

Mode: select the dewarp mode: “Fisheye” or “Wide Angle”.

Fisheye:

- **Check Condition Number:** check the validity of the condition number.
- **Fix Skew:** the skew coefficient (alpha) is set to zero and stays at zero.
- **Recompute Extrinsic:** the extrinsic is recomputed after each iteration of intrinsic optimization.

Wide Angle:

- **Fix Aspect Ratio:** the functions consider only fy as a free parameter. The ratio fx/fy stays the same as in the input camera matrix.
- **Fix Principal Point:** the principal point is not changed during the global optimization.
- **Zero Tangential Distortion:** the tangential distortion coefficients (p1,p2) are both set to zero and stay at zero.

Select Images to Calibrate: select multiple images to calibrate. The result is saved to the default location, which can be customized in the “Edit/Preferences/Calibration Settings” menu.

4.7.5.2 Dewarp - Distortion Correction

The “**Distortion Correction”** tab enables the user to load a YAML file with distortion correction values:

- Click the “**Load from File”** button.
- Select the YAML file, which is generated by the calibration.
- Configure one-time parameters.

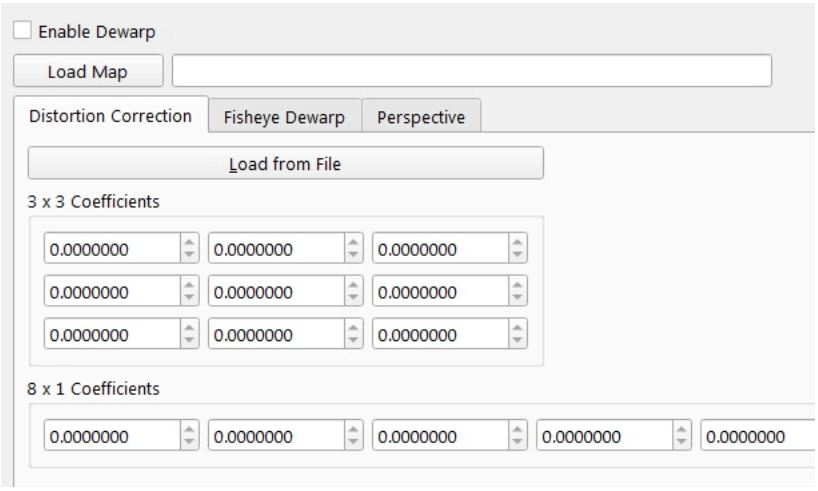

Figure 44. Dewarp - Distortion Correction

Figure 45. Distorted image and corrected image

4.7.5.3 Dewarp - Fisheye Dewarp

The “**Fisheye Dewarp”** tab enables the user to select the fisheye dewarp mode.

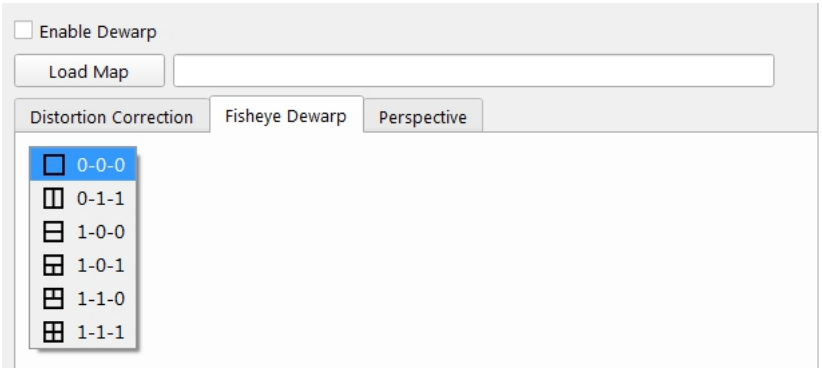

Figure 46. Dewarp - Fisheye Dewarp

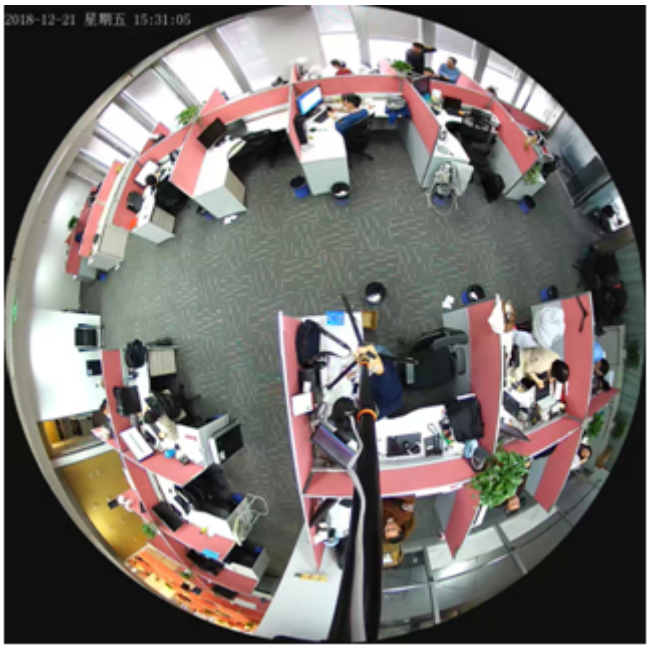

Figure 47. Original image

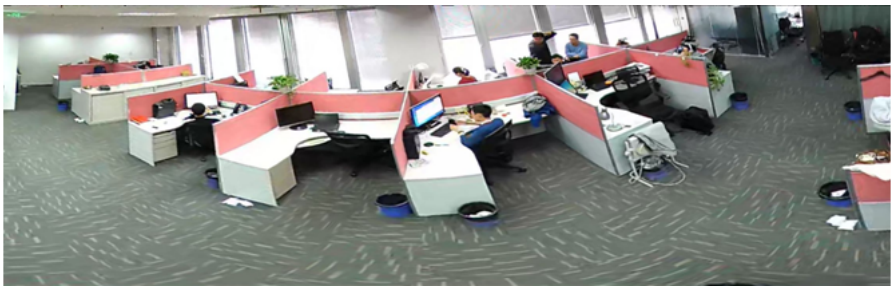

Figure 48. Fisheye - mode 1

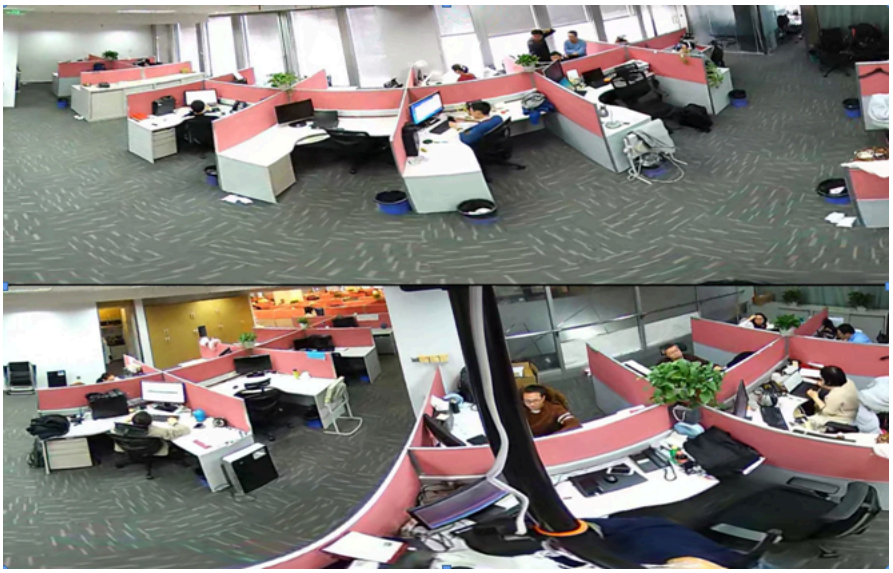

Figure 49. Fisheye - mode 2

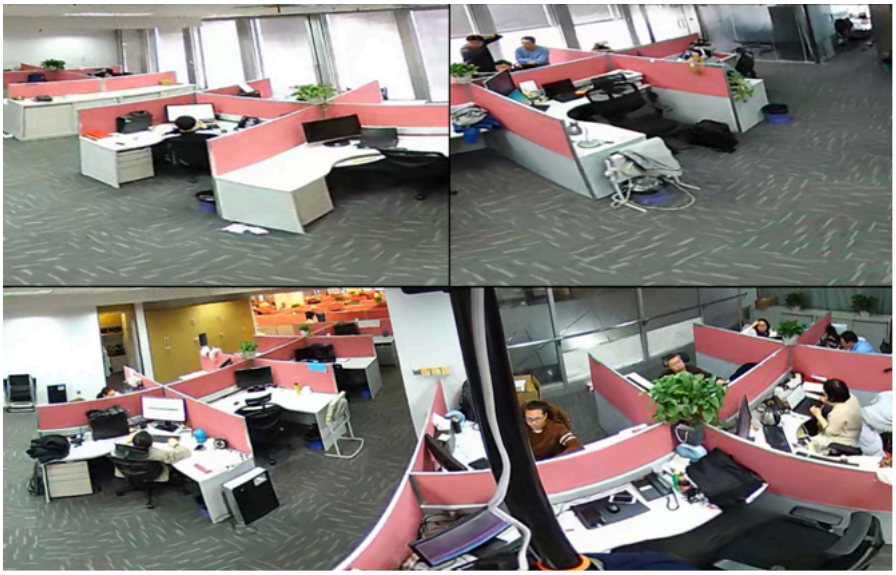

Figure 50. Fisheye - mode 3

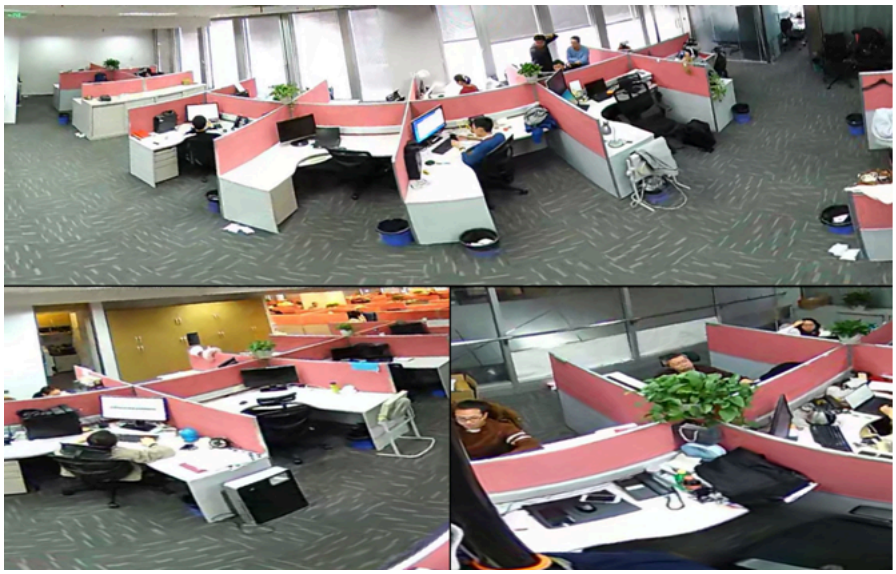

Figure 51. Fisheye - mode 4

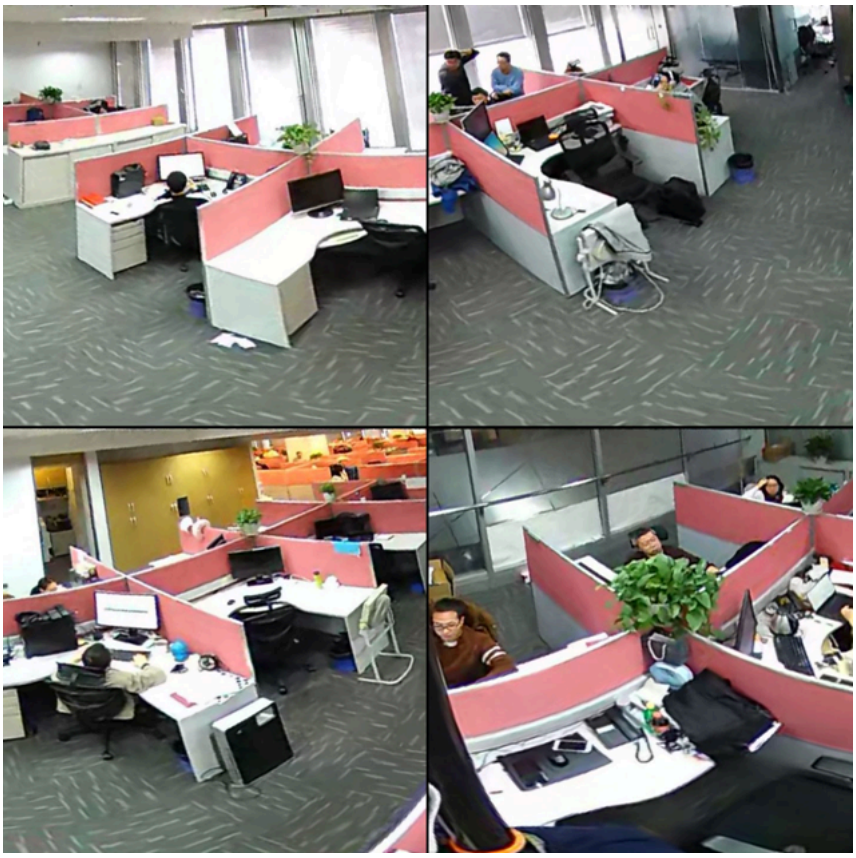

Figure 52. Fisheye - mode 5

4.7.5.4 Dewarp – Perspective

The “**Perspective”** tab enables the user to load a YAML file with perspective-correction values:

- Click the “**Load from File”** button.
- Select the YAML file, which is generated by the calibration.
- Configure one-time parameters.

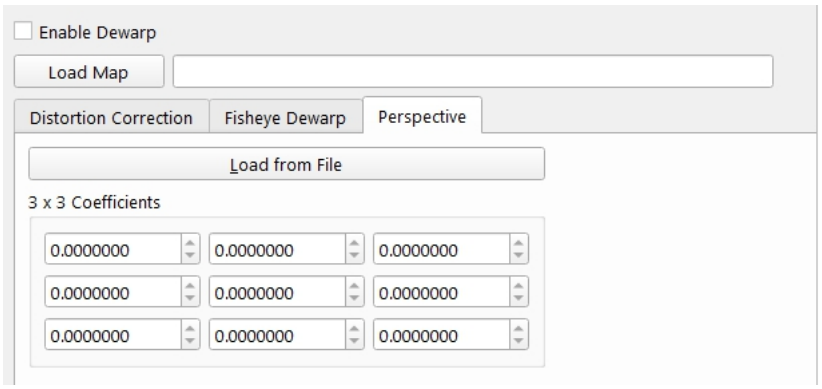

Figure 53. Dewarp - Perspective

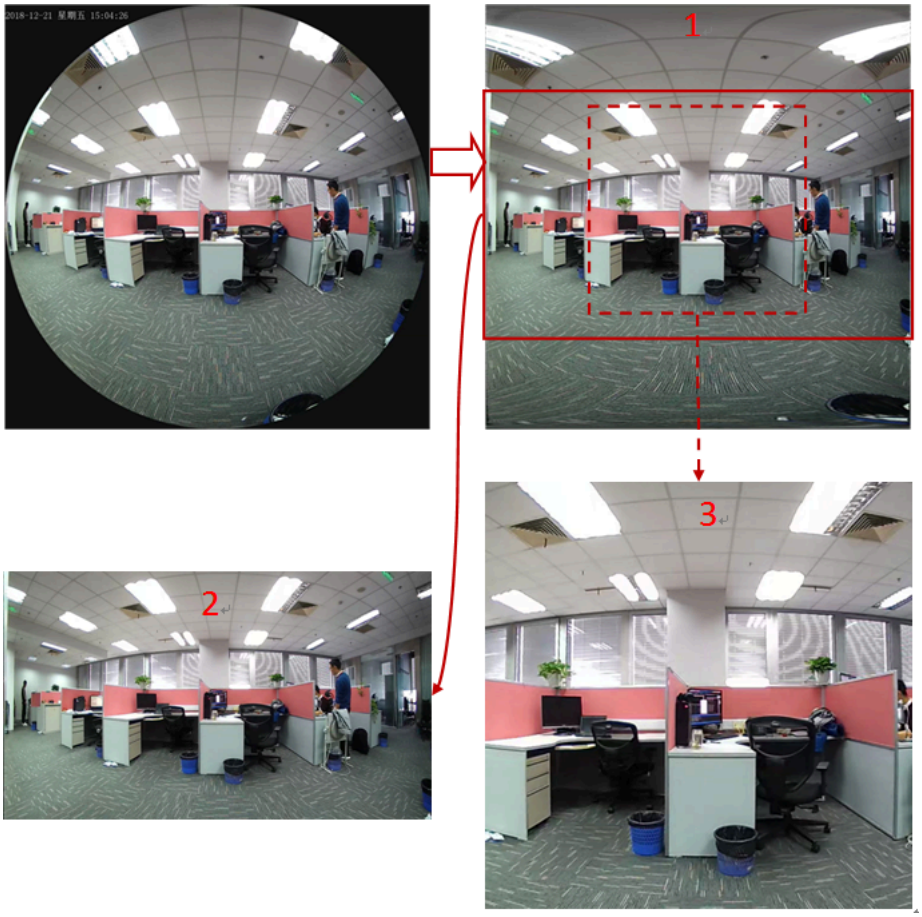

Figure 54. Original image and perspective-corrected image

5 Exported calibration XML settings

This section describes the calibration settings for the **<*tuning*>** section which is automatically generated in the calibration XML file when the Section 4.2.2 menu item is selected in the ISP Tuning Tools.

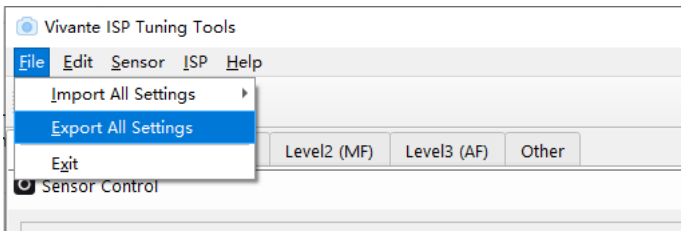

Figure 55. File - Export All Settings

The **<*tuning*>** section in the calibration XML allows the users to fine tune settings in the Image Signal Processor (ISP) module.

Examples of sections of a calibration XML file:

```
<?xml version="1.0" ?>
<matfile>
    <header type="struct" size="[1 1]">
        <creation_date index="1" type="char" size="[1 11]">
        <creator index="1" type="char" size="[1 2]">
        <sensor_name index="1" type="char" size="[1 6]">
        <sample_name index="1" type="char" size="[1 5]">
        <generator_version index="1" type="char" size="[1 4]">
        <resolution index="1" type="cell" size="[1 1]">
    </header>
    <sensor type="struct" size="[1 1]">
        <AWB index="1" type="struct" size="[1 1]">
        <LSC index="1" type="cell" size="[1 5]">
        <CC index="1" type="cell" size="[1 6]">
        <AF index="1" type="struct" size="[1 1]">
        <AEC index="1" type="struct" size="[1 1]">
        <BLS index="1" type="cell" size="[1 1]">
        <DEGAMMA index="1" type="cell" size="[1 1]">
        <WDR index="1" type="struct" size="[1 1]">
        <CAC index="1" type="cell" size="[1 1]">
        <DPF index="1" type="cell" size="[1 1]">
        <DPCC index="1" type="cell" size="[1 1]">
    </sensor>
    <system type="struct" size="[1 1]">
        <AFPS index="1" type="struct" size="[1 1]">
    </system>
```

Figure 56. Example of XML File <header>/<sensor>/<system> Sections

```
1304     <tuning>
1305         <ae enable="true" bypass="true">
1313         <af enable="true">
1316         <avs/>
1317         <awb enable="true">
1322         <bls bypass="true">
1328         <cac enable="true"/>
1329         <cnr enable="false">
1333         <cproc enable="false">
1336         <dehaze/>
1337         <demosaic enable="true">
1340         <dewarp enable="false"/>
1341         <dnr2/>
1342         <dnr3/>
1343         <dpcc enable="true"/>
1344         <dpf enable="false" adaptive="true">
1352         <ee/>
1353         <filter enable="true" auto="true">
1358         <gc enable="true">
1361         <hdr enable="false">
1365         <ie/>
1366         <images>
1371         <inputs>
1377         <lsc enable="false" adaptive="false"/>
1378         <paths>
1410         <sensors>
1420         <simp enable="true"/>
1421         <wb>
1435         <wdr>
1448     </tuning>
1449 </matfile>
```

Figure 57. Example of XML File <tuning> Section

Note: *The **<header>**, **<sensor>**, and **<system>** sections in the calibration XML are generated by the XML Generator from the ISP Calibration Tool. It is prohibited to modify the settings. For detailed information about parameters, see the "Vivante.AppNote.ISP.Sensor.Calibration.Parameter.Specification" document.*

5.1 XML <tuning> section features

The ***<tuning>*** section allows the user to view and modify numerical and logical settings for all ISP modules.

Parameters may be modified for the following features:

Level 2 Tab – Manual Functions (MF):

- High Dynamic Range (HDR)
- Exposure Control (EC)
- Black Level Subtraction (BLS)
- Lens Shading Correction (LSC)
- White Balance (WB)
- Wide Dynamic Range 3 (WDR3)
- Defect Pixel Cluster Correction (DPCC)
- Denoising Prefilter (DPF)
- Demosaic
- Filter
- Chromatic Aberration Correction (CAC)
- Color Noise Reduction (CNR)
- Gamma Correction (GC)

- Color Processing (CPROC)

Level 3 Tab – Automatic Functions (AF):

- Automatic Exposure (AE)
- Automatic Focus (AF)
- Automatic White Balance (AWB)

Parameters for the following modules are for internal use and may not be modified:

- Edge Enhancement (EE) - *Note: this feature is not available for NXP M865*
- Image Effects (IE) - *Note: this feature is not available for NXP M865*
- Automatic Video Stabilization (AVS) - *Note: this feature is not available for NXP M865*
- Dewarp
- Paths
- Inputs
- Images
- Dehaze
- Super Impose Module (Simp)

Note: *Dewarp, Paths, Inputs, Images, Dehaze and Super Impose Module parameters are included here for completeness and are not detailed in the document.*

5.1.1 High Dynamic Range (HDR)

HDR is a technology that improves the range of color and contrast in a digital image. It may be used for both photographs and videos, though the implementations are different.

```
<hdr enable="false">
    <exposure.ratio>16</exposure.ratio>
    <extension.bit>3</extension.bit>
</hdr>
```

Figure 58. High Dynamic Range (HDR) syntax

Table 1. Details of the High Dynamic Range (HDR) syntax

Parameter	Description	Valid Values
enable	Enable/disable HDR.	“true” “false”
exposure.ratio	Sets the ratio between two exposures.	[0..16]
extension.bit	Sets the number of extended bits for short exposure. Increasing the extension bit means a larger dynamic range.	[0..4]

5.1.2 Exposure Control (EC)

EC manually controls the sensor gain and integration time when Automatic Exposure is disabled.

```
<sensors>
    <sensor>
        <driver.file>ov2775.drv</driver.file>
        <ec>
            <gain>0</gain>
            <integration.time>0</integration.time>
        </ec>
        <test.pattern>false</test.pattern>
    </sensor>
</sensors>
```

Figure 59. Exposure Control (EC) syntax

Table 2. Details of the Exposure Control (EC) syntax

Parameter	Description	Valid Values
driver.file	Current sensor driver filename.	<sensor>.drv
gain	Total gain of the sensor.	*sensor-specific*
integration.time	Integration time of the sensor.	*sensor-specific*
test.pattern	Enable or disable the sensor test pattern.	true false

5.1.3 Black Level Subtraction (BLS)

The black level offsets are sensor-specific and are the results of the sensor calibration and tuning process.

Note: *Modification of the Black Level offsets on this level should only be done by experts.*

```
<bls bypass="false">
    <red>64</red>
    <green.b>64</green.b>
    <green.r>64</green.r>
    <blue>64</blue>
</bls>
```

Figure 60. Black Level Subtraction (BLS) syntax

Table 3. Details of the Black Level Subtraction (BLS) syntax

Parameter	Description	Valid Values
bypass	Bypass the BLS module.	“true” “false”
red	The black level subtraction value of the red channel.	*sensor-specific*
green.b	The black level subtraction value of the green_b channel.	*sensor-specific*
green.r	The black level subtraction value of the green_r channel.	*sensor-specific*
blue	The black level subtraction value of the blue channel.	*sensor-specific*

5.1.4 Lens Shading Correction (LSC)

Using **LSC**, your software can remove image structures that originate in the imaging system that do not belong to the actual image information.

```
<lsc enable="false" adaptive="false"/>
```

Figure 61. Lens Shading Correction (LSC) syntax

Table 4. Details of the Lens Shading Correction (LSC) syntax

Parameter	Description	Valid Values
enable	Enable/disable LSC.	“true” “false”
adaptive	Reserved	N/A

5.1.5 White Balance (WB)

WB is used to adjust values manually for White Balance if Automatic White Balance is disabled.

```
<wb>
    <cc.matrix>
    [1.8049999475479126,-0.53899997472763062,-0.25,-0.47699999809265137,
    1.7890000343322754,-0.23399999737739563,0.016000000759959221,-0.6330
    0001621246338,1.7339999675750732]</cc.matrix>
    <cc.offset>
        <blue>0</blue>
        <green>0</green>
        <red>0</red>
    </cc.offset>
    <wb.gains>
        <blue>2.1989999</blue>
        <green.b>1.016</green.b>
        <green.r>1.016</green.r>
        <red>1.887</red>
    </wb.gains>
</wb>
```

Figure 62. White Balance (WB) syntax

Table 5. Details of the White Balance (WB) syntax

Parameter	Description	Valid Values
cc.matrix	Color Correction Matrix values.	[-8, 7.992]
cc.offset	Color Correction offset values for blue, green, and red.	[-2048, 2047]
wb.gains	White Balance gains. for blue, green.b, green.r, and red.	[0.000, 3.999]

5.1.6 Wide Dynamic Range 3 (WDR3)

WDR3 is local tone mapping module based on entropy calculation method. It is used to enhance images to make significantly more content visible, especially for dark scenes. At the same time, it will retain and improve good local contrast and global contrast. It is mainly used in the scenes with high dynamic range, such as a backlit face or landscapes with large shadow regions.

```
<wdr>
    <v1 enable="true">
        <d.y>[0,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4,4]
        </d.y>
        <y.m>
        [0,124,248,372,496,620,744,868,992,1117,1241,1365,1489,1613,1737,1861,1985
        ,2110,2234,2358,2482,2606,2730,2854,2978,3103,3227,3351,3475,3599,3723,384
        7,3971]</y.m>
    </v1>
    <v3 enable="true" auto="false">
        <auto.level>65535</auto.level>
        <gain.max>15</gain.max>
        <strength>15</strength>
        <strength.global>15</strength.global>
        <table>{"columns":["HDR","Gain","Integration Time","Strength","Max
        Gain","Global Curve"],"rows":[]}</table>
    </v3>
</wdr>
```

Figure 63. Wide Dynamic Range 3 (WDR3) syntax

Table 6. Details of the Wide Dynamic Range 3 (WDR3) syntax

Parameter	Description	Valid Values
v1	V1 parameters are used to set Global WDR (GWDR).	
enable	Enable/disable GWDR	“true” “false”
d.y	Tone Mapping Curve parameter d.y.	d.y[0]=0, d.y[1,33]=4
y.m	Tone Mapping Curve parameter y.m.	[0, 4095]
v3	v3 parameters are used to set WDR.	
enable	Enable/disable WDR	“true” “false”
auto	Automatic or manual mode.	“true” “false”
auto.level	Set the level of automatic adjustments.	
gain.max	WDR maximum gain.	Dynamic range is [0, 128]; default: 16.
strength	WDR strength.	Dynamic range is [0, 128]; default: 100.
strength.global	WDR global strength.	Dynamic range is [0, 128]; default: 100.
table	Reserved.	N/A

5.1.7 Defect Pixel Cluster Correction (DPCC)

DPCC is used to enable/disable Defect Pixel Cluster Correction.

```
<dpcc enable="true"/>
```

Figure 64. Defect Pixel Cluster Correction (DPCC) syntax

Table 7. Details of the Defect Pixel Cluster Correction (DPCC) syntax

Parameter	Description	Valid Values
enable	Enable/disable DPCC.	“true” “false”

5.1.8 Denoising Prefilter (DPF)

DPF is used to enable/disable Denoising Prefilter and configure DPF strength and weight parameters.

Note: *Modification of the Denoising Prefilter values should only be done by experts.*

```
<dpf enable="false" adaptive="true">
    <division.factor>64</division.factor>
    <gradient>0.15000001</gradient>
    <minimum.bound>2</minimum.bound>
    <offset>0</offset>
    <sigma.green>4</sigma.green>
    <sigma.red.blue>4</sigma.red.blue>
</dpf>
```

Figure 65. Denoising Prefilter (DPF) syntax

Table 8. Details of the Denoising Prefilter (DPF) syntax

Parameter	Description	Valid Values
enable	Enable/disable DPF.	“true” “false”
adaptive	Reserved.	N/A
DPF strength parameters used to calculate denoise strength:		
division.factor	Used to calculate denoise strength.	[0 … 64]
gradient	Used to calculate denoise strength.	[0 … 128]
minimum.bound	Used to calculate denoise strength.	[0 … 128]
offset	Used to calculate denoise strength.	[-128 … 128]
	DPF weight parameters:	
sigma.green	The spatial filter’s sigma of the green channel.	[1 … 255]
sigma.red.blue	The spatial filter’s sigma of the red/blue channel.	[1 … 255]

5.1.9 Demosaic

Demosaic is used to enable/disable Demosaicing and set the texture detection threshold.

```
<demosaic enable="true">
    <threshold>0</threshold>
</demosaic>
```

Figure 66. Demosaic syntax

Table 9. Details of the Demosaic syntax

Parameter	Description	Valid Values
enable	Enable/disable Demosaic.	“true” “false”
threshold	The threshold for Bayer demosaicing texture detection.	[0..255] where: 0: maximum edge sensitivity

Table 9. Details of the Demosaic syntax...*continued*

Parameter	Description	Valid Values
		255: no texture detection

5.1.10 Filter

Filter is used to enable/disable Filter and adjust denoising and sharpening filtering values.

```
<filter enable="true" auto="true">
    <denoise>1</denoise>
    <sharpen>3</sharpen>
    <table>{"columns":["HDR","Gain","Integration
    Time","Denoising","Sharpening"],"rows":[]}</table>
</filter>
```

Figure 67. Filter syntax

Table 10. Details of the Filter syntax

Parameter	Description	Valid Values
enable	Enable/disable Filter.	“true” “false”
auto	Automatic or manual mode.	“true”: Automatic mode “false”: Manual mode
denoise	Denoise level.	[0..10]
sharpen	Sharpening level	[0..10]
table	Reserved.	N/A

5.1.11 Chromatic Aberration Correction (CAC)

CAC is used to enable/disable Chromatic Aberration Correction (CAC).

```
<cac enable="true"/>
```

Figure 68. Chromatic Aberration Correction (CAC) syntax

Table 11. Details of the Chromatic Aberration Correction (CAC) syntax

Parameter	Description	Valid Values
enable	Enable/disable Chromatic Aberration Correction (CAC).	“true” “false”

5.1.12 Color Noise Reduction (CNR)

CNR is used to enable/disable CNR and set threshold values for color channels 1 and 2.

```
<cnr enable="false">
    <threshold.tc.1>0</threshold.tc.1>
    <threshold.tc.2>0</threshold.tc.2>
</cnr>
```

Figure 69. Color Noise Reduction (CNR) syntax

Table 12. Details of the Color Noise Reduction (CNR) syntax

Parameter	Description	Valid Values
enable	Enable/disable Color Noise Reduction (CNR).	“true” “false”
threshold.tc.1	The color noise removal threshold value of the Cb channel.	[0 … 32767]
threshold.tc.2	The color noise removal threshold value of the Cr channel.	[0 … 32767]

5.1.13 Gamma Correction (GC)

GC is used to enable/disable GC and set scaling mode and curve.

```
<gc enable="true">
    <curve>AQAAAAAASQCJALcA3wAfAVQBgwGtAfYBNQJvAtMCKgN4A78D/wMAAA==</curve>
</gc>
```

Figure 70. Gamma Correction (GC) Syntax

Table 13. Details of the Gamma Correction (GC) syntax

Parameter	Description	Valid Values
enable	Enable/disable Gamma Correction (GC).	“true” “false”
curve	Sets the gamma curve value.	[0 … 1023]

5.1.14 Color Processing (CPROC)

CPROC is used to enable/disable CPROC and set color processing values for contrast, brightness, saturation, and hue.

```
<cproc enable="false">
    <config>AQAAAAEAAAABAAAAzcyMP/EAAAAAAIA/AAAAAA==</config>
</cproc>
```

Figure 71. Color Processing (CPROC) Syntax

Note: *The CPROC parameter is encoded and should not be changed in the XML file.*

Table 14. Details of the Color Processing (CPROC) syntax

Parameter	Description	Valid Values
enable	Enable/disable Color Processing (CPROC).	“true” “false”
contrast	Sets contrast.	[0 … 1.9921875] Default: 1 Greater than 1: increases contrast; less than 1 decreases contrast.
brightness	Sets brightness.	[-128 … 127] Default: 0 Greater than 0: increases brightness; less than 0 decreases brightness.

Table 14. Details of the Color Processing (CPROC) syntax...*continued*

Parameter	Description	Valid Values
saturation	Sets saturation.	[0 … 1.9921875] Default: 1 Greater than 1: increases saturation; less than 1 decreases saturation.
hue	Sets hue.	[-90 … 89] Default: 0 Greater than 0: increases hue; less than 0 decreases hue.

5.1.15 Automatic Exposure (AE)

AE automatically controls the sensors gain and integration time to achieve a well-exposed image.

```
<ae enable="true" bypass="true">
    <afps>false</afps>
    <flicker.period>1</flicker.period>
    <damping.over>0.2</damping.over>
    <damping.under>0.30000001</damping.under>
    <set.point>80</set.point>
    <tolerance>20</tolerance>
    <weight>[1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1]</weight>
</ae>
```

Figure 72. Automatic Exposure (AE) Syntax

Table 15. Details of the Automatic Exposure (AE) syntax

Parameter	Description	Valid Values
enable	Enable/disable Automatic Exposure (AE).	“true” “false”
bypass	Bypass AE parameters configuration.	“true” “false”
afps	Enable or disable Adaptive Frame Per Second	true false
flicker.period	Flicker period.	[0..2] 0: Flicker Period off 1: 100 Hz 2: 120 Hz
damping.over	The damping factor, which is used to smooth the exposure value of the front and back frames. Use this parameter when the measure value > set.point.	[0 … 1.0]
damping.under	Use damping.under when the measure value <= set.point. Note: damping.over <= damping.under.	[0 … 1.0]
set.point	Target value of auto exposure control.	[0 … 255]
tolerance	Tolerance of brightness changes; when brightness changes > tolerance, that is $\frac{\lvert m_0 - m_{meas} \rvert}{m_0} > tolerance$, adjust the exposure value.	[0 … 100]
weight	The weight coefficient of regions.	[0 ... 16]

5.1.16 Automatic Focus (AF)

AF is used to enable/disable Automatic Focus if the sensor supports auto-focus.

```
<af enable="true">
    <algorithm oneshot="false">2</algorithm>
    <position>37</position>
    <mode>1</mode>
</af>
```

Figure 73. Automatic Focus (AF) syntax

Table 16. Details of the Automatic Focus (AF) syntax

Parameter	Description	Valid Values
enable	Enable/disable Automatic Focus (AF).	“true” “false”
algorithm	Selects the automatic focus search algorithm.	1: full range 2: adaptive range 3: hill climbing
oneshot	Selects one shot mode to run auto-focus one time.	“true” “false”
position	Focal length	[0 ... 100]
mode	Working mode of sensor	1: manual 2: auto

5.1.17 Automatic White Balance (AWB)

AWB is used to automatically control the digital gain and color correction of the ISP. It also adapts the lens shading and the color saturation with respect to the selected or detected illumination.

```
<awb enable="true">
    <damping>true</damping>
    <index>4</index>
    <mode>2</mode>
</awb>
```

Figure 74. Automatic White Balance (AWB) syntax

Table 17. Details of the Automatic White Balance (AWB) syntax

Parameter	Description	Valid Values
enable	Enable/disable Automatic White Balance (AWB).	“true” “false”
damping	Changes white balance smoothly through temporal damping.	true false
index	Selects the Illumination Profile.	0: A 1: D50 2: D65 3: F2(CWF)

Table 17. Details of the Automatic White Balance (AWB) syntax*...continued*

Parameter	Description	Valid Values
		4: F11(TL84)
mode	Selects the White Balance mode, manual or automatic.	1: manual 2: auto

6 Revision history

The table below summarizes the revisions to this document.

Table 18. Revision history

Revision number	Date	Substantive changes
4	16 August 2023	• Updated to a newer revision of tuning tool (4.3.3.P22.1)
3	12 December 2022	• Added support for LF5.15.52_2.1.0 • Updated Figure 15 • Updated Figure 29 • Updated Exposure Control (EC) syntax (in Section 5.1.2) • Added note
2	23 August 2022	• Added support for LF5.15.35_2.1.0 • Template change and editorial updates
1	15 December 2021	• Supports LF5.10.72_2.2.0 • Added section Section 1.3 • Updated Figure 3, Figure 14, Figure 19, and Figure 35 • Added details information on the calibration setting in the XML file. • Removed JPEG raw file capture and added YUV format support. • Updated Section 4.7.3.5.
0	18 May 2021	Initial release

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