# Outline

- I. Module Spec
- II. Module Select
- III. Basic tuning verify

CONFIDENTIAL B

# I. Module Spec

CONFIDENTIAL B

# AE Basic Sensor Check

Version: V1.0
Release date: 2017-05-15

# Document Revision history

| Revision | Date | Description |
|---|---|---|
| V1.0 | 2017-05-12 | • First version |

# Outline

- Purpose
- Raw Data Collection Method
- Raw Data Analysis
- Q&A

# PURPOSE

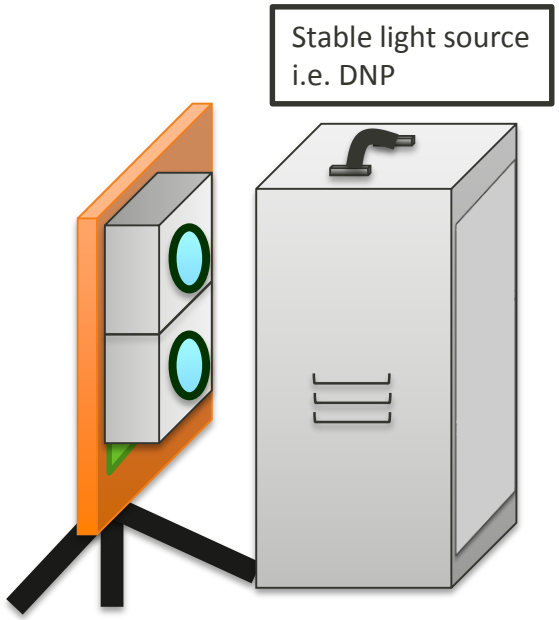
# Purpose

- This document provides an image sensor specification for:
  - Bayer + Bayer dual cam modules.
  - Bayer + Mono dual cam modules
- It describes image sensor **linearity check method & Color Relation(B+M only)** for dual camera modules.
- Image sensor in dual camera must satisfy this specification, then it can be used for dual camera.

# LINEARITY CHECK

# Environment Setting

- Light condition requirements:
  - Uniform & stable light source.
  - Color temperature: between 5000K ~ 6500K.
  - Brightness: LV10
  - Recommended light source: DNP Light box

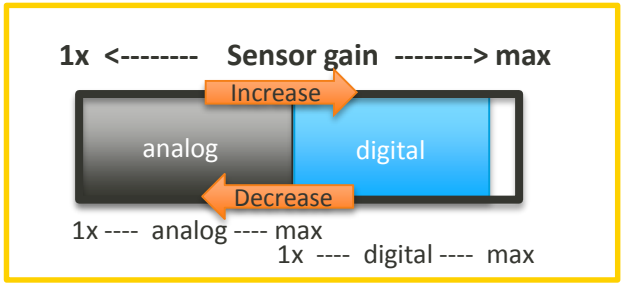


# Camera Setting

- Camera Setting:
  - Shading: OFF
  - OB: OFF
  - Check image area:  Center 100*100 pixels

# Exposure/Gain

- This specification needs several capturing with different exposure/gain settings.
  - Item1: **Fix gain** and change exposure time.
    - Increase exposure time and capture raw.
    - The increased time step interval is:
      - 8333 us if light box 60 Hz
      - 5000 us if light box 50 Hz or else.
  - Item2: **Fix exposure time** and change sensor gain.
    - Increase sensor gain and capture raw.
    - The increase gain interval is minimum sensor register step.
    - Increase/decrease rule:
      - **Increase:** Analog gain first, and then digital gain.
      - **Decrease:** Digital gain first, and then analog gain.



Gain increase/decrease rule

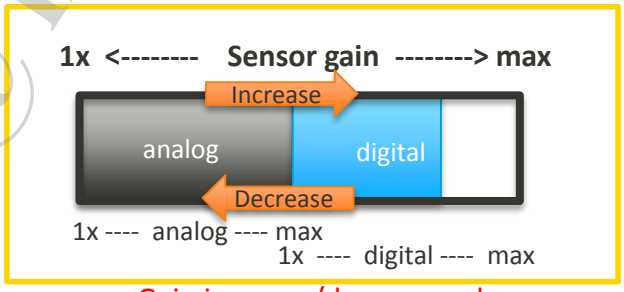
# Check Item 1

- Check item 1:
  1. Set main2 sensor fixed 1x gain
  2. Set main2 exposure time (T) to achieve G-channel/W-channel around 8~12 digital value in 10-bit, and this value is after OB.
  3. Set main1 camera with the same exposure setting as main2.
  4. Capture raw images for dual camera.
  5. Increase dual camera exposure time 5ms, and capture raw images for dual camera.
  6. Repeat step 5. for capture raw until exposure time maximum or image saturation.

- Collect data:
  - A serial raw images with different exposure time interval 5ms for dual camera.

# Check Item 2

- Check item 2:
  1. Set main2 sensor fixed 32x gain.
  2. Set main2 exposure time (T) to achieve G-channel/W-channel saturation level(95%~99%), and this value is after OB.
  3. Set main1 camera with the same exposure setting as main2.
  4. Capture raw images for both camera.
  5. Decrease both camera sensor gain with minimum register step, and capture raw images for both camera. (please follow the "Gain increase/decrease rule" to +/- gain)
  6. Repeat step 5. until gain 1x.



Gain increase/decrease rule

- Collect data:
  - A serial raw images with different gain for dual camera.

# RAW DATA ANALYSIS

# Raw Data Analysis

- Use tool to see if the capture result can pass spec.

- Here provide a Tool folder, and it contains:
  - DllUsageExample:
    - Put dual camera raw data in specified folders with proper naming, this tool can output the verification result.

# Raw Data File
## Folder & Naming Rule

- Put main1 raw files in “DllUsageExample/bin/TestData/Sensor1” folder
- Put main2 raw files in “DllUsageExample/bin/TestData/Sensor2” folder
- Rename File, the naming rule as below:

• **Naming rule for Check item 1:**

**ExposureShutter_RGB_widthxheight_xxxxxx.raw**

--- for Bayer raw files (xxxxxx could be arbitrary extra information, but not too long(<20 characters))

--- Ex. **10000_RGB_4208X3120_20161207_161100.raw**

**ExposureShutter_Mono_widthxheight_xxxxxx.raw**

--- for mono raw files (xxxxxx could be arbitrary extra information, but not too long (<20 characters))

--- Ex. **10000_Mono_4208X3120_20161207_161100.raw**

• **Naming rule for Check item 2:**

**SensorGain_RGB_widthxheight_xxxxxx.raw**

--- for Bayer raw files (xxxxxx could be arbitrary extra information, but not too long(<20 characters))

--- Ex. **8x_RGB_4208X3120_20161207_161100.raw**

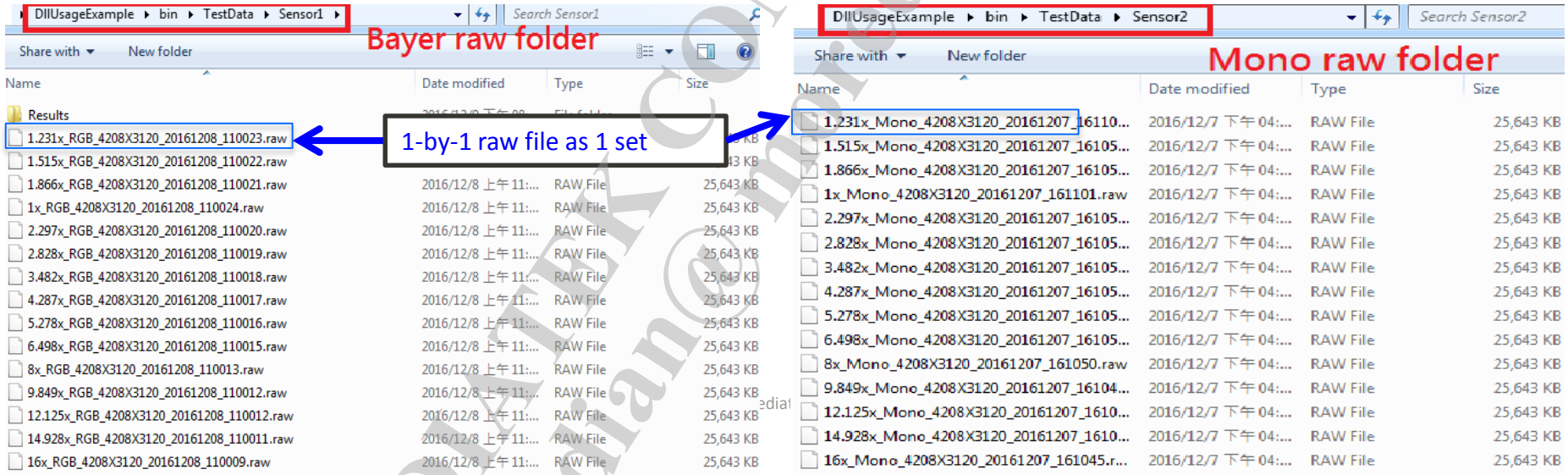
**SensorGain_Mono_widthxheight_xxxxxx.raw**

--- for mono raw files (xxxxxx could be arbitrary extra information, but not too long (<20 characters))

--- Ex. **8x_Mono_4208X3120_20161207_161100.raw**

# Raw Data File Folder & Naming Rule

- Example:

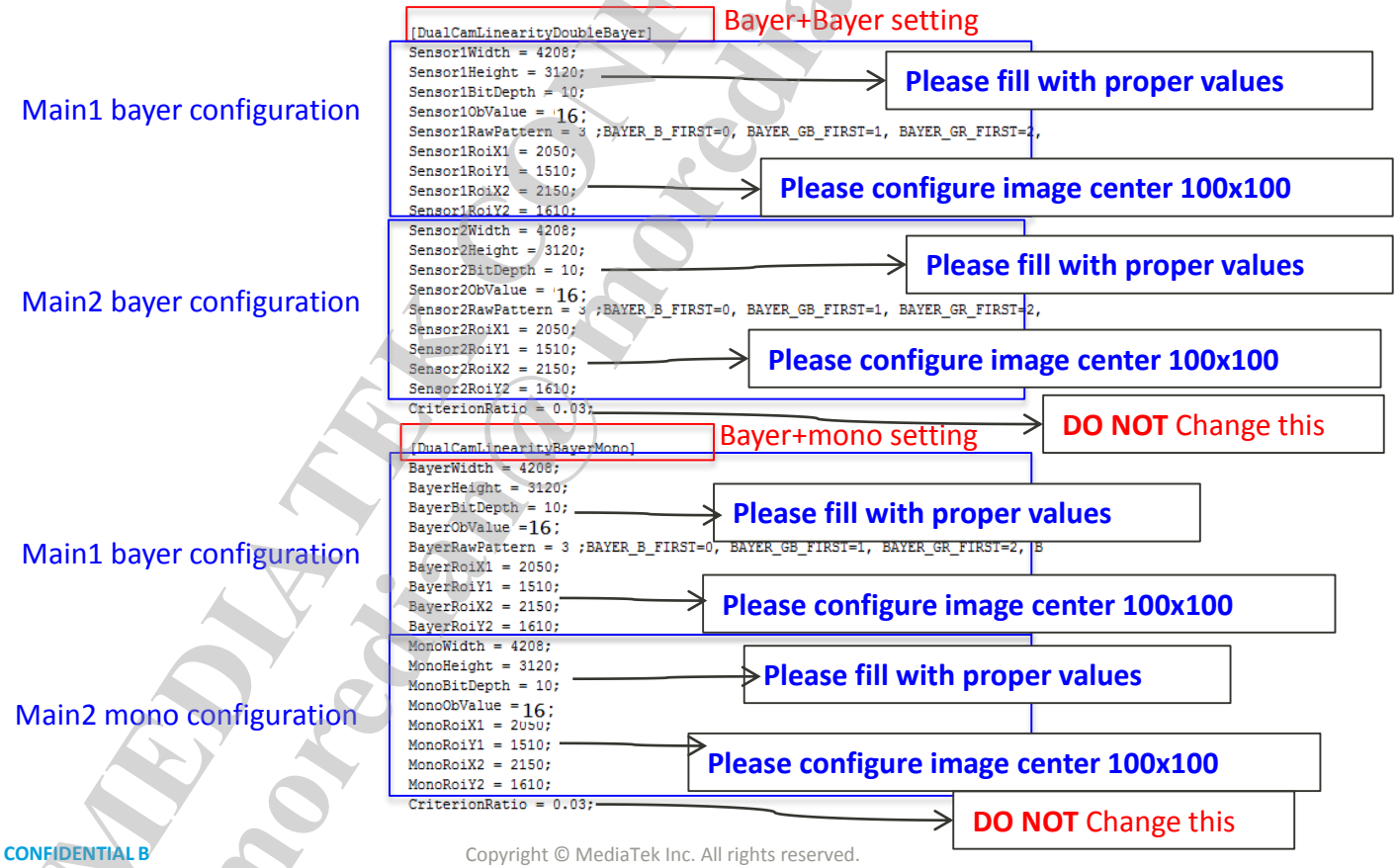


# Raw Data Analysis Configure file

- Find *.ini file “**LibMtkSensorQualification**” in folder “DllUsageExample\bin”

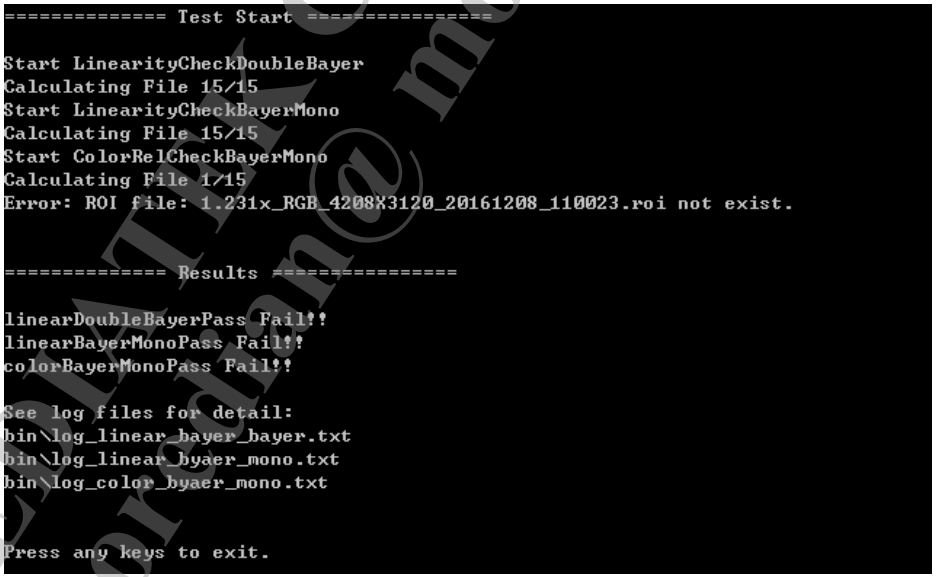
# Raw Data Analysis
# Edit Configure file

- Notice:
  - For B+B dual camera: Keep only B+B setting and remove B+M part.
  - For B+M dual camera: keep B+M setting and remove B+B part.



# Raw Data Analysis
# Run Test

- Execute “ApplicationExample.exe” in folder DllUsageExample\bin
  - You’ll see the process window as below, and there will be three log files generated:
    - log_color_byaer_mono.txt
    - log_linear_bayer_bayer.txt
    - log_linear_bayer_mono.txt
  - Only one log file that meets your sensor type should be considered (log_linear_bayer_bayer.txt or log_linear_bayer_mono.txt) and ignore the rest files



# Raw Data Analysis
# Log File

- Output
  - Pass / fail (each set must meet Criteria: ±3%)
  - Log File Format

**B+B Sensor**

Avg. B1/B2, G1/G2,R1/R2

```
[Avg.]
AvgRatio: B:0.644428, G:1.424150, R:0.672489
====================================
[RawSet 1]
Sensor1: B:172.034805, G:239.882599, R:177.527603
Sensor2: B:253.643600, G:165.266006, R:251.346405
Ratio1/2: BB:0.678254, GG:1.451494, RR:0.706307
RatioVar: BB:5.2%, GG:1.9%, RR:5.0%
Result:Failed
====================================
[RawSet 2]
Sensor1: B:181.913193, G:255.532806, R:187.817200
Sensor2: B:281.697205, G:179.856400, R:278.961212
Ratio1/2: BB:0.645776, GG:1.420760, RR:0.673274
RatioVar: BB:0.2%, GG:-0.2%, RR:0.1%
Result:Pass
================================
...
```

B+B statistic values of two sensors with the same exposure shutter

**B+W Sensor**

Avg. G/B, G/R, W/B

Avg. W/G, W/R

```
[Avg.]
AvgRatio: GB:1.407280, GR:1.360961, WB:1.267102, WG:0.900370,
WR:1.225411
====================================
[RawSet 1]
Bayer: B:172.034805, G:239.882599, R:177.527603
Mono: W:208.880493
RatioB/B: GB:1.394384, GR:1.351241
RatioVar: GB:-0.9%, GR:-0.7%
RatioM/B: WB:1.214176, WG:0.870761, WR:1.176609
RatioVar: WB:-4.2%, WG:-3.3%, WR:-4.0%
Result:Failed
====================================
[RawSet 2]
Bayer: B:181.913193, G:255.532806, R:187.817200
Mono: W:230.092804
RatioB/B: GB:1.404696, GR:1.360540
RatioVar: GB:-0.2%, GR:-0.0%
RatioM/B: WB:1.264849, WG:0.900443, WR:1.225089
RatioVar: WB:-0.2%, WG:0.0%, WR:-0.0%
Result:Pass
================================
...
```

B+M statistic values of two sensors with the same exposure shutter

# Raw Data Analysis
## Analysis Of Failed Case

- If test result is failed:
  - Check if *.ini file setting is proper (ex. bit depth, OB value, ROI area…)
  - Check if exposure value(shutter time) of that case is valid for both sensors.
  - Further, need to be discussed.

# Q&A

- Q1: When camera sensor/lens of dual cam are different, the same exposure setting for both cam will have different brightness results in 2 camera, even to be over-exposure, is that OK?
- A1: Yes, it is OK.

# Q&A

- Q2: If the gain increase/decrease interval is very small, the test will need hundreds of captures. Is it OK for analyzing tool to input so many raw files?
- A2: Yes, it is OK.

- Q3: If gain interval in digital is 1x, 2x, 4x…., and makes gain changing interval bigger than analog gain, for example, 1x, 1.25x, 1.5x… 8x, 16x, 32x, is it OK?
- A3: Yes, it is OK.

# Q&A

- Q4: If test with phone, how to set the exposure setting?
- A4: Please use following ADB commands to set exposure time, analog gain(sensor gain), and digital gain (isp gain)..

```
adb shell setprop debug.ae_mgr.enable 1
adb shell setprop debug.ae_mgr.preview.update 1
adb shell setprop debug.ae_mgr.shutter 10          ← exposure time: unit: us,  i.e. 8333 us
adb shell setprop debug.ae_mgr.sensorgain 2048  ← analog gain, 1024 base,  i.e. 1x =1024,  2x =2048…
adb shell setprop debug.ae_mgr.ispgain 1024        ← digital gain, 1024 base,  i.e. 1x =1024,  2x =2048…
```

# COLOR RELATION

# Color Relation Check
# Step 1 : Capture Pure Raw of Bayer & Mono Sensor

Scenario:

ColorChecker put in the center of image (occupy 1/9 of whole image)

Lighting condition :

D65, CWF, TL84, A, Hor

Exposure control:

Control exposure make

Mono sensor #19 around saturation level * 80%

Bayer's exposure is **the same** with Mono


Total: 10 "**Pure Raw**" data (Bayer = 5, Mono = 5)

# Color Relation Check

## Step 2 : Put Bayer & Mono Raw Data in Different Folders With Proper Naming

•You can put the captured Bayer raw files in arbitrary folder and put mono raw files in another, but file naming must follow the rule,and some example's shown below

• Naming rule:

Lightsource-B__widthxheight_bit depth_bayer type.raw for Bayer raw files

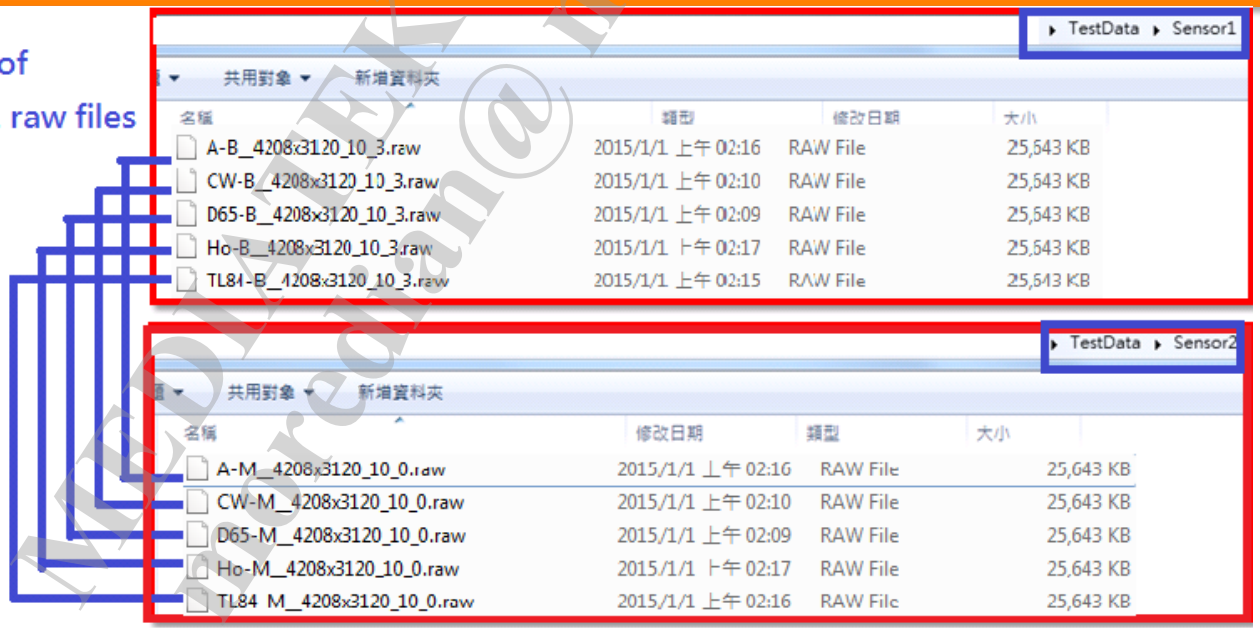
Ex. D65-B__4208x3120_10_3.raw

Lightsource-M__widthxheight_bit depth_bayer type.raw for Mono raw files

Ex. D65-M__4208x3120_10_3.raw

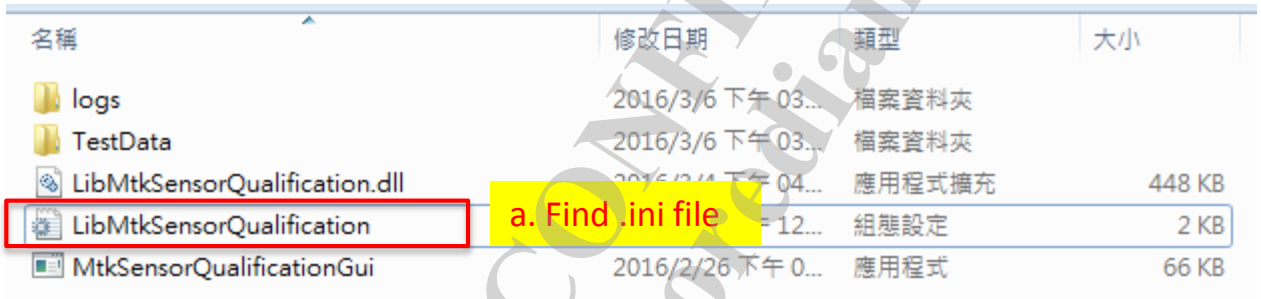
5 sets of

1-by-1 raw files



# Color Relation Check
# Step 3 : Edit .ini File

- Find .ini file in **ColorRelationTestProgram** Folder




b. Find the tag "DualCamColorRelationBayerMono"

```
[DualCamColorRelationBayerMono]
BayerWidth = 4208;
BayerHeight = 3120;
BayerBitDepth = 12;
BayerObValue = 64;
BayerRawPattern = 3 ;BAYER_B_FIRST=0, BAYER_GB_FIRST=1, BAYER_GR_FIRST=2, BAYER_R_FIRST=3, MONO=4
MonoWidth = 4208;
MonoHeight = 3120;
MonoBitDepth = 12;
MonoObValue = 64;
CriterionRatio = 0.05;
```

Fill in Bayer Sensor Information

OB value, base on raw data bit depth

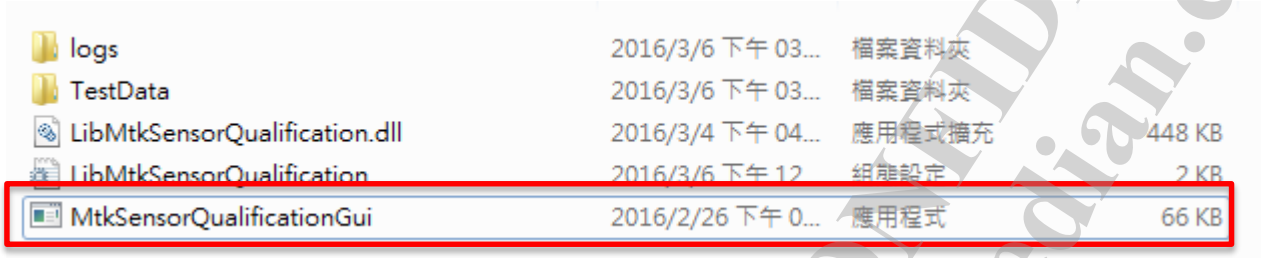
Fill in Mono Sensor Information

OB value, base on raw data bit depth

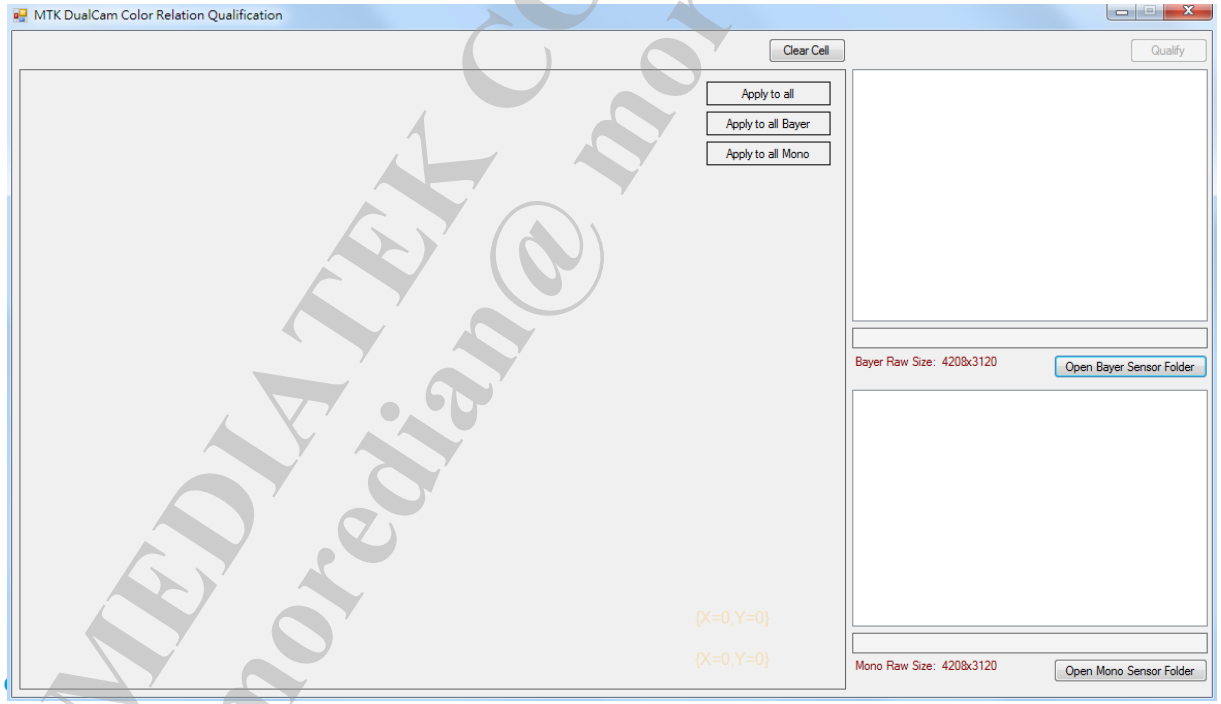
Pass Criterion, **DO NOT** Modify it!

c. Close .ini file after editing

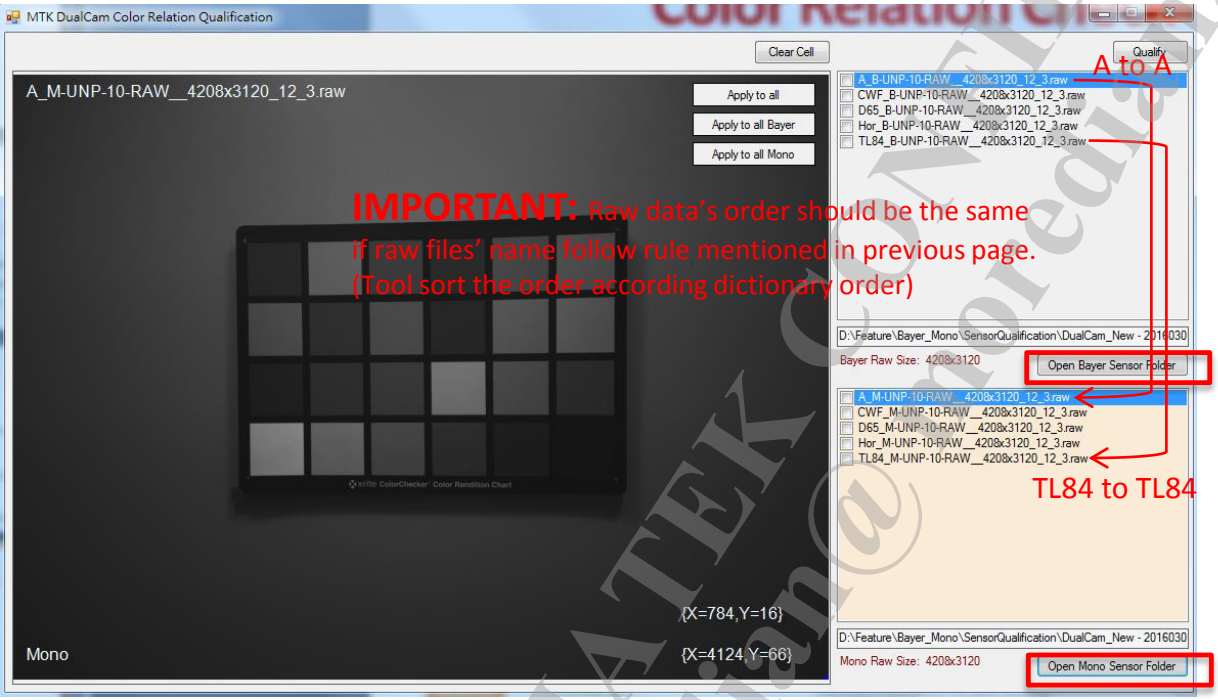
# Color Relation Check
## Step 4 : Execute Tool

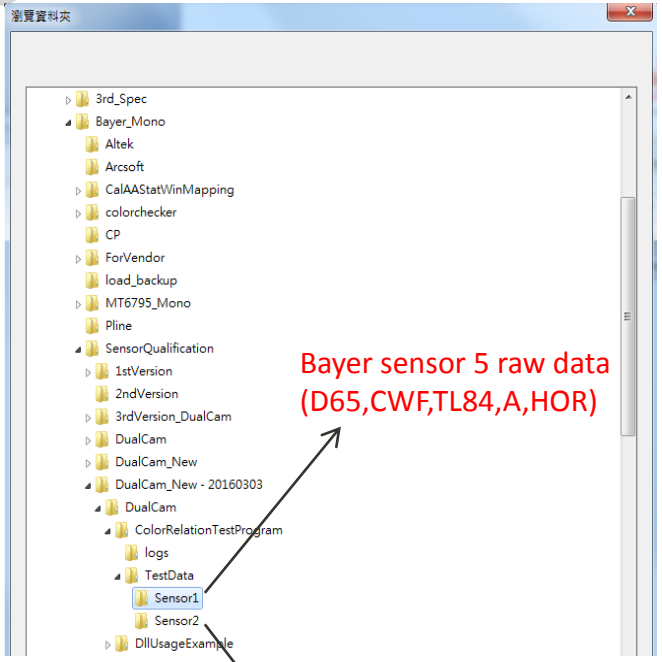



Double click to execute program



# Color Relation Check
## Step 5: Load Raw Data

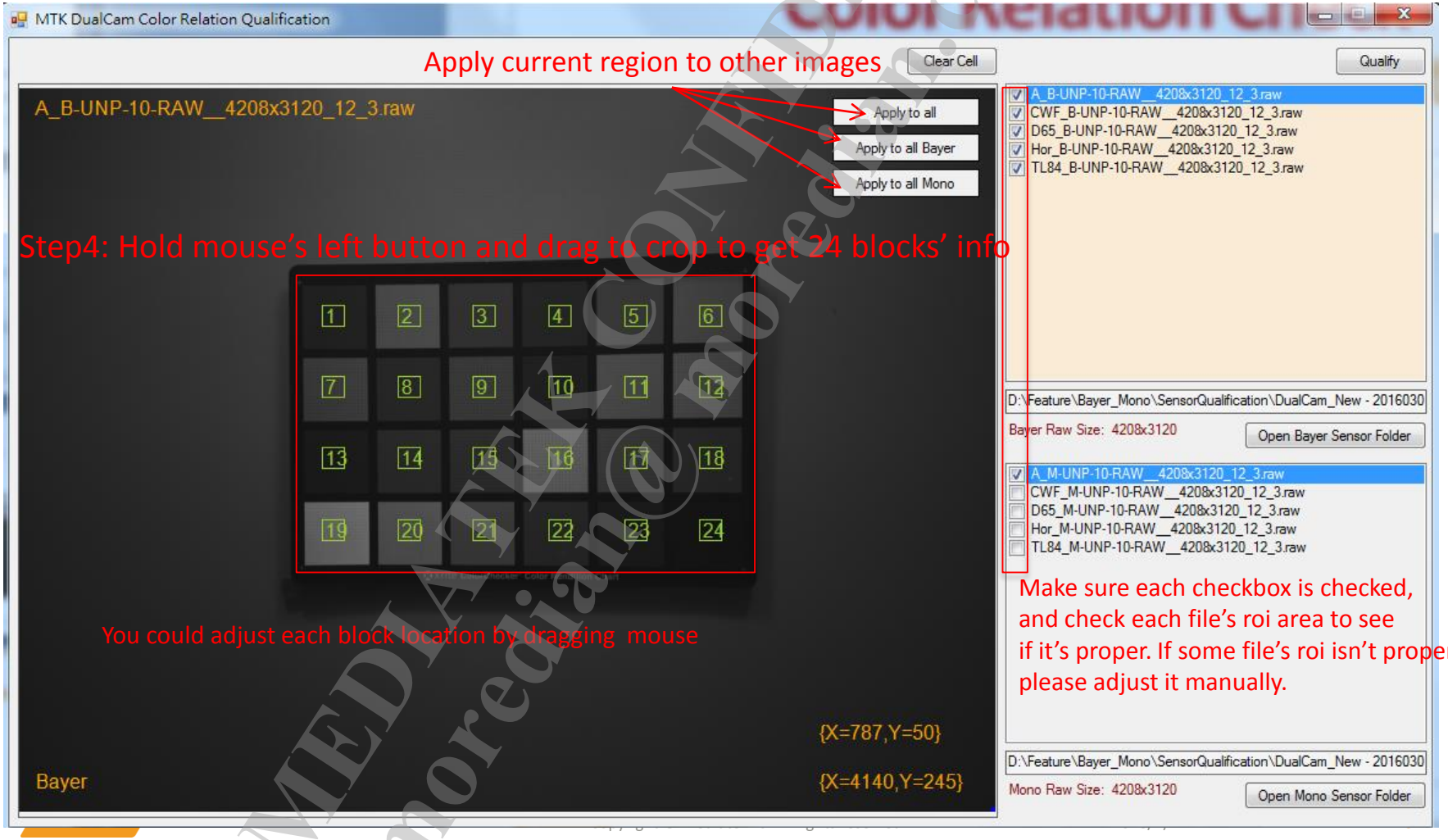



Bayer sensor 5 raw data
(D65,CWF,TL84,A,HOR)

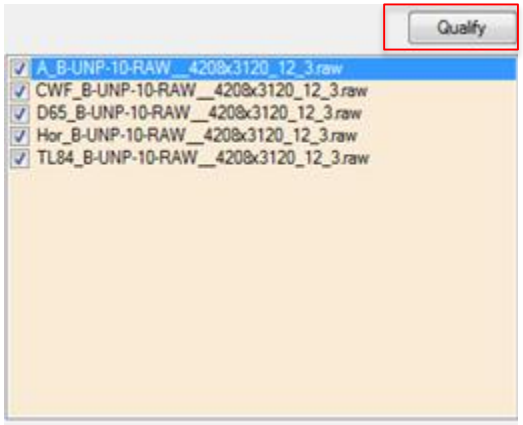
Mono sensor 5 raw data
(D65,CWF,TL84,A,HOR)

# Color Relation Check
# Step 6: Get Image Information



# Color Relation Check
# Step7: Check Result Log File

Press qualify button to generate result





UI will show result is pass or fail

You could check log file in folder ColorRelationTestProgram\logs for more detail

```
[Environment]
BayerPath: F:\SW3\DualCamTech\Titan-meeting\SensorVerifyDemo0215\ColorRelationTestProgram\TestData\sensor1\
MonoPath: F:\SW3\DualCamTech\Titan-meeting\SensorVerifyDemo0215\ColorRelationTestProgram\TestData\sensor2\
[Coefficients]
Conversion formula: W = xR + yG + zB
RGB to W coefficients: x:0.916545, y:0.898799, z:1.118138
Raw bit depth: 10
Pass Criterion: |W/RGBtoW|/1024 < 5.00%
====================================
[RawSet 1]
[ColorCell#1]
Bayer: B:35.540779, G:98.949257, R:104.633423
Mono: W:214.500946
RGBtoW :224.576233
Ratio :0.98%
Result:Pass
-------------------------
[ColorCell#2]
Bayer: B:100.704391, G:269.620148, R:301.021729
Mono: W:619.768738
RGBtoW :630.835693
Ratio :1.08%
Result:Pass
-------------------------
[ColorCell#3]
Bayer: B:85.829338, G:169.674576, R:106.657799
Mono: W:334.154877
RGBtoW :346.229095
Ratio :1.18%
Result:Pass
```

x,y,z coefficients

Test information

Avg. R/G/B value of the block of bayer raw

Avg. W of the block of mono raw

RGBtoW = conversion R/G/B to W

100*ABS(RGBtoW – monoW)/2^(bit depth) %

Check if Ratio < Pass criteria

Each block calculation info

# Color Relation Check
# Step 8: Analysis Of Failed Case

- If test result is failed:
  - Check if .ini file's setting is proper (ex. bit depth, OB value…)
  - Check if roi area of each raw/block is proper
  - Check if exposure value(shutter/gain) of that case is valid for both bayer and mono sensors
  - Further, need to be discussed

# Color Relation Check
## Step 9: Trouble shooting - I

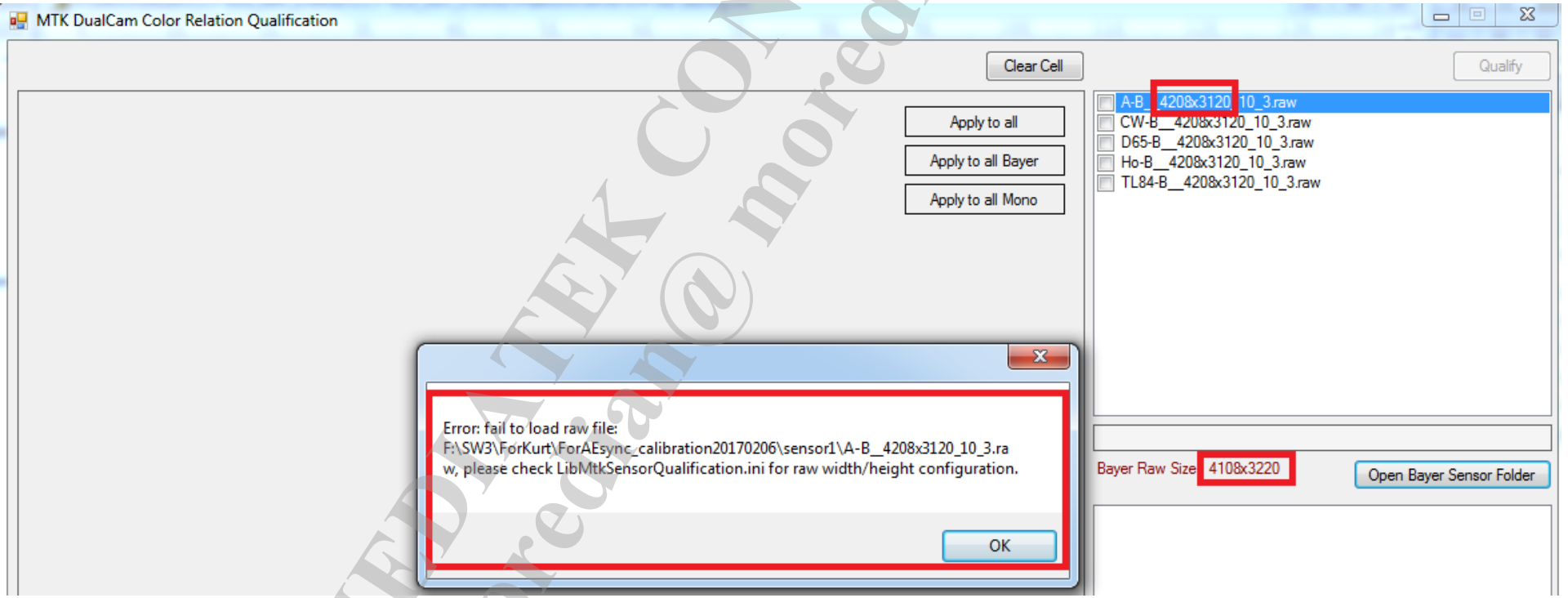
- If fill wrong bit depth, there might be mess or too dark loading raw result
  - Ex. Correct bit depth = 10


Set bit depth =8


Set bit depth =12

# Color Relation Check
## Step 9: Trouble shooting - II

- If fill wrong sensor size, you'll see error msg or mess loading result, please correct file size in .ini




*everyday genius*

CONFIDENTIAL B

# Camera Module Check for Auto Focus

Version: V1.0
Release date: 2017-11-29

# Document Revision history

| Revision | Date | Description |
|---|---|---|
| V1.0 | 2017-11-29 | • First version<br>• Merge "*AF basic module check*" & "*Lens Motor quality Check*" to this document. |

# Purpose

- **Basic check**
  - Check general auto focus camera module.
  - It is designed to guarantee that auto focus can work well.

- **Advance check**
  - Check camera module auto focus VCM quality.
  - It is designed to guarantee that VCM is good enough for application, i.e. dual cam with open loop VCM auto focus .
  - For auto focus abnormal issues, this method can also be used to check potential problems in VCM.

# Outline

1. **Basic check** (general module check)
    1. Module Variation
    2. VCM Settling time
    3. OTP Accuracy
    4. Mechanical check

2. **Advance check** (especially for open loop VCM check)
    1. Linearity Test
    2. Black lash/Hysteresis Test
    3. Accuracy Repeatability/Reliability Test
    4. Lens Posture/Gravity Test

# Basic Check

# Basic Check

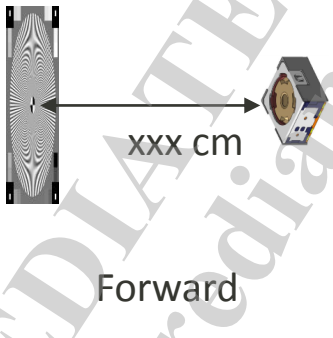
- Basic module check (general module check)
  1. Module Variation
  2. VCM Settling time
  3. OTP Accuracy
  4. Mechanical check

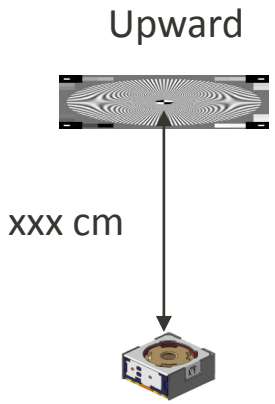
# 1. Module Variation

- Here list the test items and test conditions:

*environment brightness >400 lux, D65

| | Item | Module direction | Test distance | Test amount |
|---|---|---|---|---|
| 1 | Module variation | Lens forward & Upward | Same as OTP calibration distance | > 100 pcs in forward or upward, and 20pcs for another direction |



# 1. Module Variation

Version | Summary | Module Variation | VCM Settling time | AF OTP Accuracy | Mechanical check | Advance check

- **Provide Data: (reference to CameraModuleCheck_for_AutoFocus.xlsx)**
  - Record the focus peak Dac* of infinite/macro when forward and upward to excel.

Fill the blank area OTP

100 pcs in forward or upward, and 20pcs for another direction

| No. | Infinite distance | | Macro distance | | Infinite | Macro |
|---|---|---|---|---|---|---|
| | Forward | Upward | Forward | Upward | Posture Diff. | |
| #1 | 376 | 382 | 762 | 743 | 6 | 19 |
| #2 | 312 | 422 | 674 | 738 | 110 | 64 |
| #3 | 296 | 382 | 686 | 734 | 86 | 48 |
| #4 | 348 | 391 | 710 | 776 | 43 | 66 |
| #5 | 308 | 394 | 690 | 732 | 86 | 42 |
| #6 | 332 | 386 | 710 | 709 | 54 | 1 |
| #7 | 332 | 387 | 686 | 759 | 55 | 73 |

*Dac: driver IC position value, if the driver IC use position code is 16bit, it should be remapped to 10bit.

For driver IC target position use 2's complement (2's 補碼), (i.e. On-semi driver IC), we must do a remapping to 0~1023.

# 1. Module Variation

Version | Summary | Module Variation | VCM Settling time | AF OTP Accuracy | Mechanical check | Advance check

## Test Spec.

- It is recommended that
  - Max(|unit – average|) < Average_OTP_Range x30%

| | | | | | | |
|---|---|---|---|---|---|---|
| | Average OTP range | | 363.4 | | | |
| | | | | | | Max Variation |
| | Infinite distance | | Macro distance | | Infinite | Macro |
| | Forward | Upward | Forward | Upward | Posture Diff. | |
| Spec | 109.02 | 109.02 | 109.02 | 109.02 | 109.02 | 109.02 |
| Max Variation(test) | 64.96 | 50.85 | 83.56 | 89.75 | 58.65 | 86.36842105 |
| % | 17.9% | 14.0% | 23.0% | 24.7% | 16.1% | 23.8% |
| | Result | max | 23.0% | Pass | | |
| | Spec | max | 30% | | | |

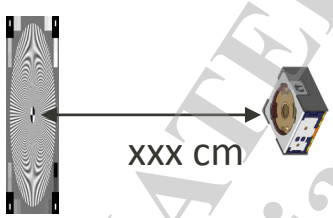
# 2. VCM Settling time(For module house)

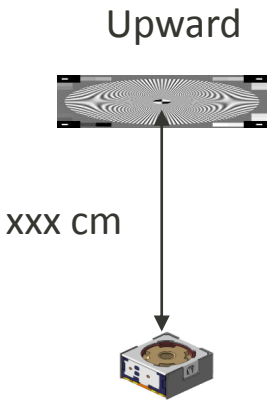
Version | Summary | Module Variation | VCM Settling time | AF OTP Accuracy | Mechanical check | Advance check

- Here list the test items and test conditions:

*environment brightness don't care

| | Item | Module setting | Test distance | Test amount |
|---|---|---|---|---|
| 2 | VCM settling time | forward or upward | N/A | 5pcs |

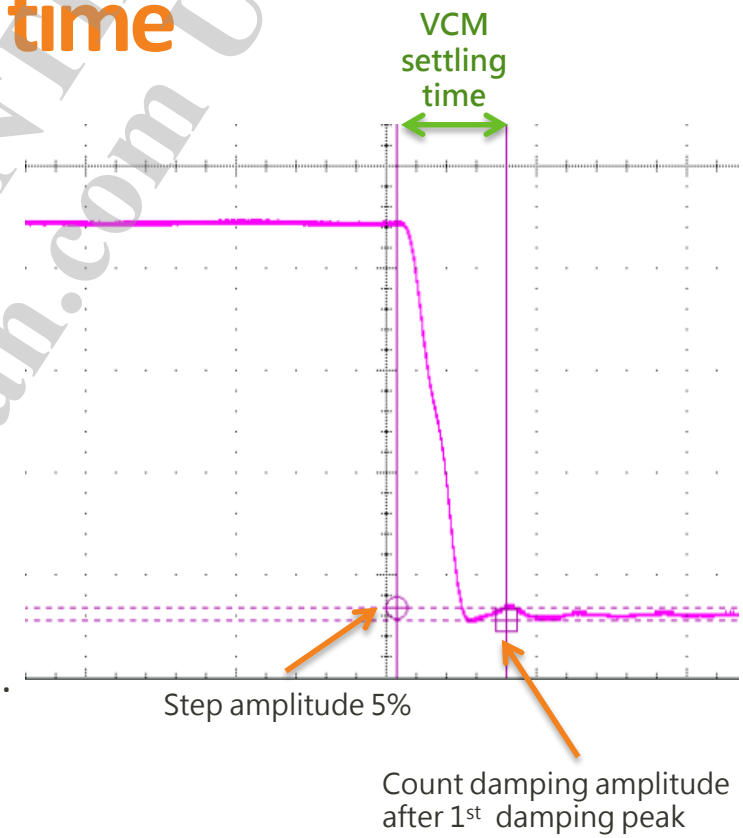


# 2. VCM Settling time

- Tools:
  - Laser meter with (1 um) accuracy
  - Test amount: 5 pcs

- Test setting and condition:
  - Module direction:  forward or upward
  - Driver IC SRC ON (if available)
  - Check 5 times for average value for each module.
  - Measurement: Amplitude < Step amplitude* 5%
  - Step size:




| Step size | Non-PD Sensor | PD Sensor |
|---|---|---|
| (OTP Macro – OTP Infinity) x 40% | X | √ |
| (OTP Macro – OTP Infinity) x 20% | X | √ |
| (OTP Macro – OTP Infinity) x 5% | √ | √ |

# 2. VCM Settling time

- **Provide data: (reference to CameraModuleCheck_for_AutoFocus.xlsx)**
  - Fill OTP data, and the start/end of lens moving 10bit dac will auto generate.
  - Fill the result VCM Settling time.

Fill OTP data

Auto generate the test Dac

Fill Test result

| OTP data | | | | |
|---|---|---|---|---|
| Infinite | Macro | StepSize 40% | StepSize 20% | StepSize 5% |
| 150 | 700 | 220 | 110 | 28 |

| Step Ratio | From | To | VCM Settling Time |
|---|---|---|---|
| 40% | 150 | 370 | 9.4 |
| | 370 | 590 | 8.6 |
| | | | |
| | 700 | 480 | |
| | 480 | 260 | |
| | | | |
| 20% | 150 | 260 | |
| | 370 | 480 | |
| | 590 | 700 | |
| | | | |
| | 700 | 590 | |
| | 480 | 370 | |
| | 260 | 150 | |
| | | | |
| 5% | 150 | 178 | |
| | 374 | 402 | |
| | 598 | 626 | |
| | | | |
| | 700 | 672 | |
| | 476 | 448 | |
| | 252 | 224 | |
| | | | |

# 2. VCM Settling time


## Test Spec.

- It is recommended that
  - Normal AF settling time < 15 ms;
  - PDAF settling time < 15 ms。

| | Step size | VCM Settling time (Unit: ms) |
|---|---|---|
| Normal AF | 40% | - |
| Normal AF | 20% | - |
| Normal AF | 5% | < 15 ms |
| Hybrid AF(PD) | 40% | < 15 ms |
| Hybrid AF(PD) | 20% | < 15 ms |
| Hybrid AF(PD) | 5% | < 15 ms |

# 3. OTP Accuracy



- Module test item:

*environment brightness >400 lux, D65

| | Item | Test scene/distance | Module direction | Test amount |
|---|---|---|---|---|
| 3 | OTP accuracy | As AF OTP calibration | As AF OTP calibration | >10pcs |


Should the same as AF OTP calibration environment

# 3. OTP Accuracy

Version | Summary | Module Variation | VCM Settling time | AF OTP Accuracy | Mechanical check | Advance check

- **Provide data: (reference to CameraModuleCheck_for_AutoFocus.xlsx)**
  - Fill the focus fine search peak dac of infinite/macro to Excel.
  - Fill the OTP value to Excel

Fill the Yellow area.

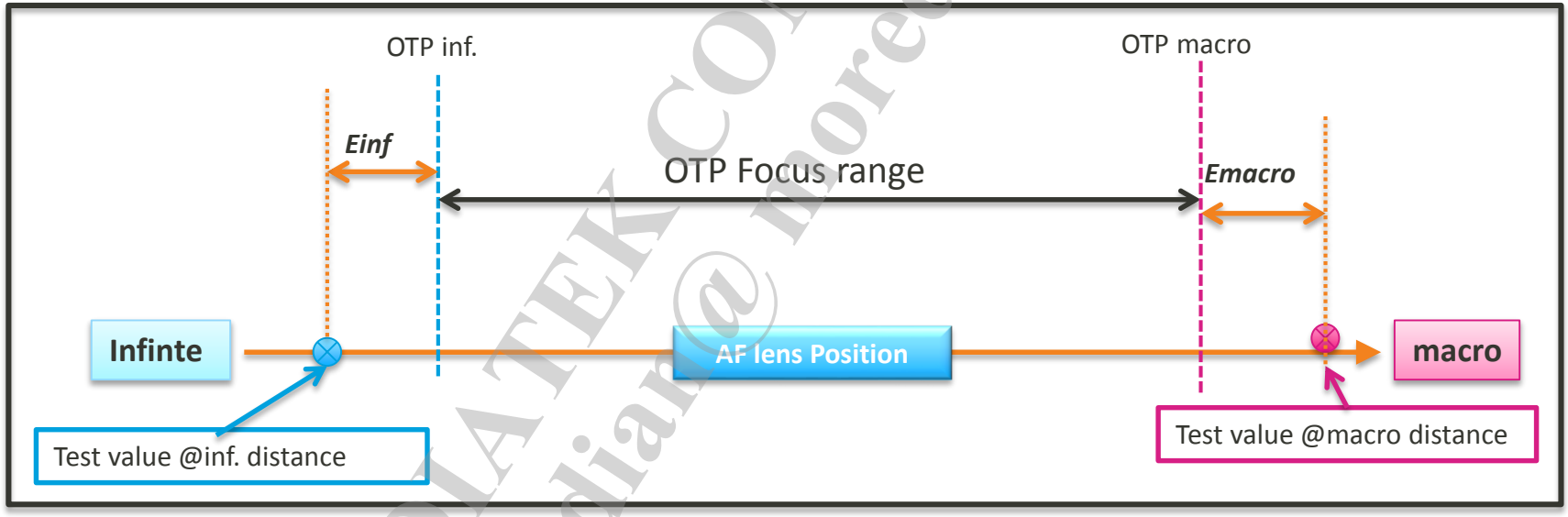
Spec:
--Both Max. errors Emacro & Max. errors Einf < (OTP Focus range *15%)
--Test quantity: >10 pcs

| Module | OTP value | | Fine search result | | | Diff | |
|---|---|---|---|---|---|---|---|
| | Infinite | Macro | Infinite | Macro | | Einf | Emacro |
| #1 | 150 | 500 | 152 | 513 | #1 | 7 | 8 |
| #2 | 160 | 510 | 150 | 523 | #2 | 5 | 18 |
| #3 | 170 | 520 | 142 | 521 | #3 | 3 | 16 |
| #4 | 180 | 530 | 170 | 500 | #4 | 25 | 5 |
| #5 | 190 | 540 | 162 | 500 | #5 | 17 | 5 |
| #6 | 100 | 460 | 140 | 550 | #6 | 5 | 45 |
| #7 | 110 | 470 | 152 | 540 | #7 | 7 | 35 |
| #8 | 120 | 480 | 152 | 545 | #8 | 7 | 40 |
| #9 | 130 | 490 | 158 | 534 | #9 | 13 | 29 |
| #10 | 140 | 550 | 157 | 510 | #10 | 12 | 5 |

# AF OTP Accuracy

Version | Summary | Module Variation | VCM Settling time | AF OTP Accuracy | Mechanical check | Advance check

- Spec:
  - Test quantity: >10 pcs
  - For each sample *k*, calculate errors $|OTP_k - TestValue_k|$ of inf. & macro.
  - For each sample, errors ***Emacro*** & ***Einf*** < (**OTP Focus range** *15%)



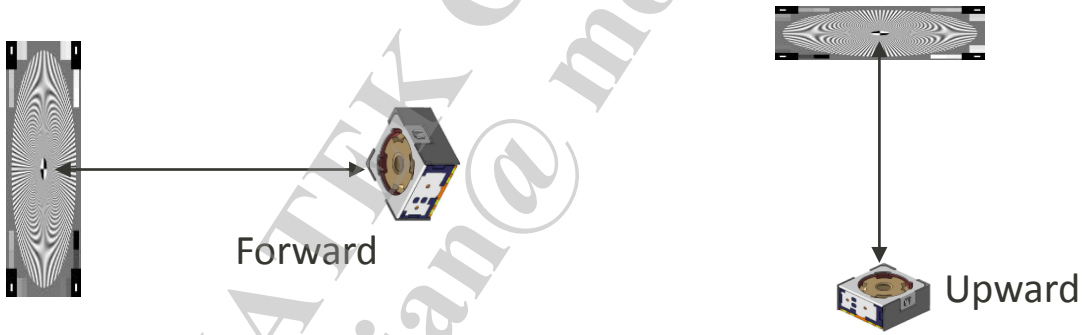
# 4. Mechanical check



- Module test item:

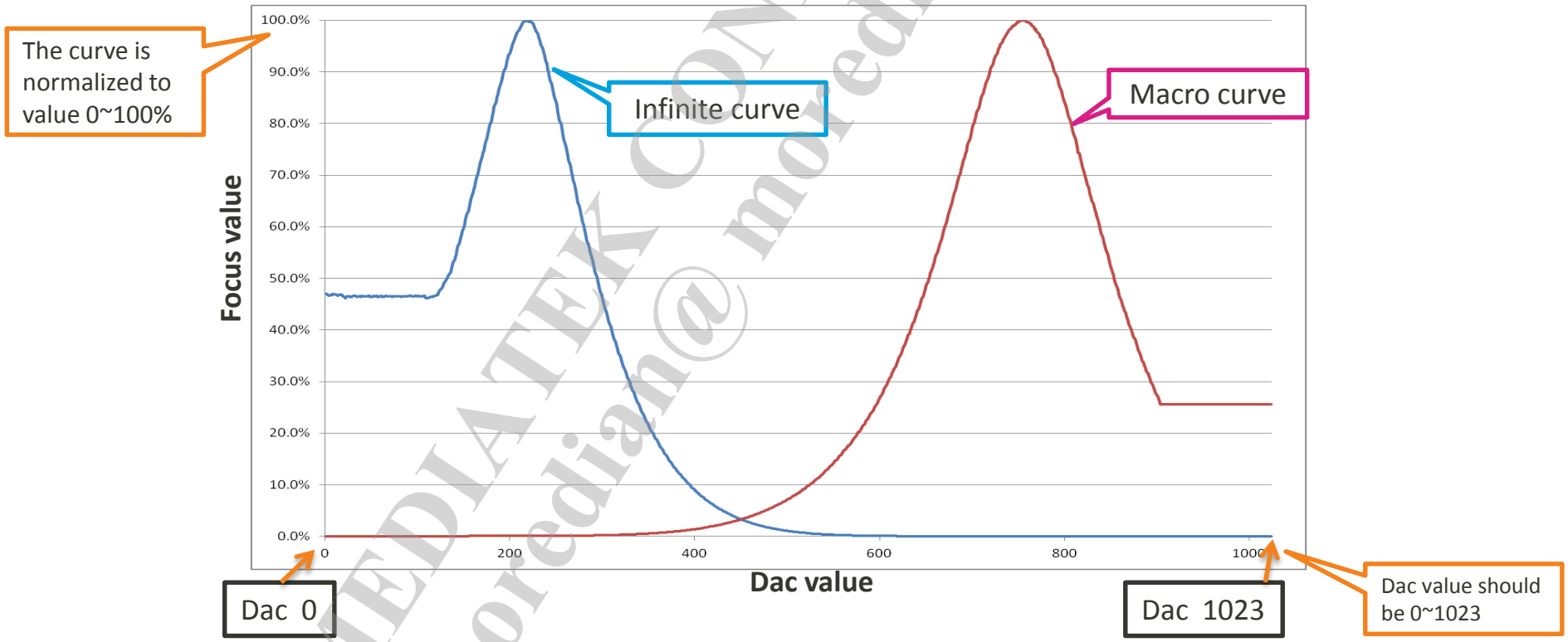
*environment brightness >400 lux, D65

| | Item | Test scene/distance | Module direction | Test amount |
|---|---|---|---|---|
| 4 | Mechanical check | As AF OTP calibration | Forward & upward | 5pcs |



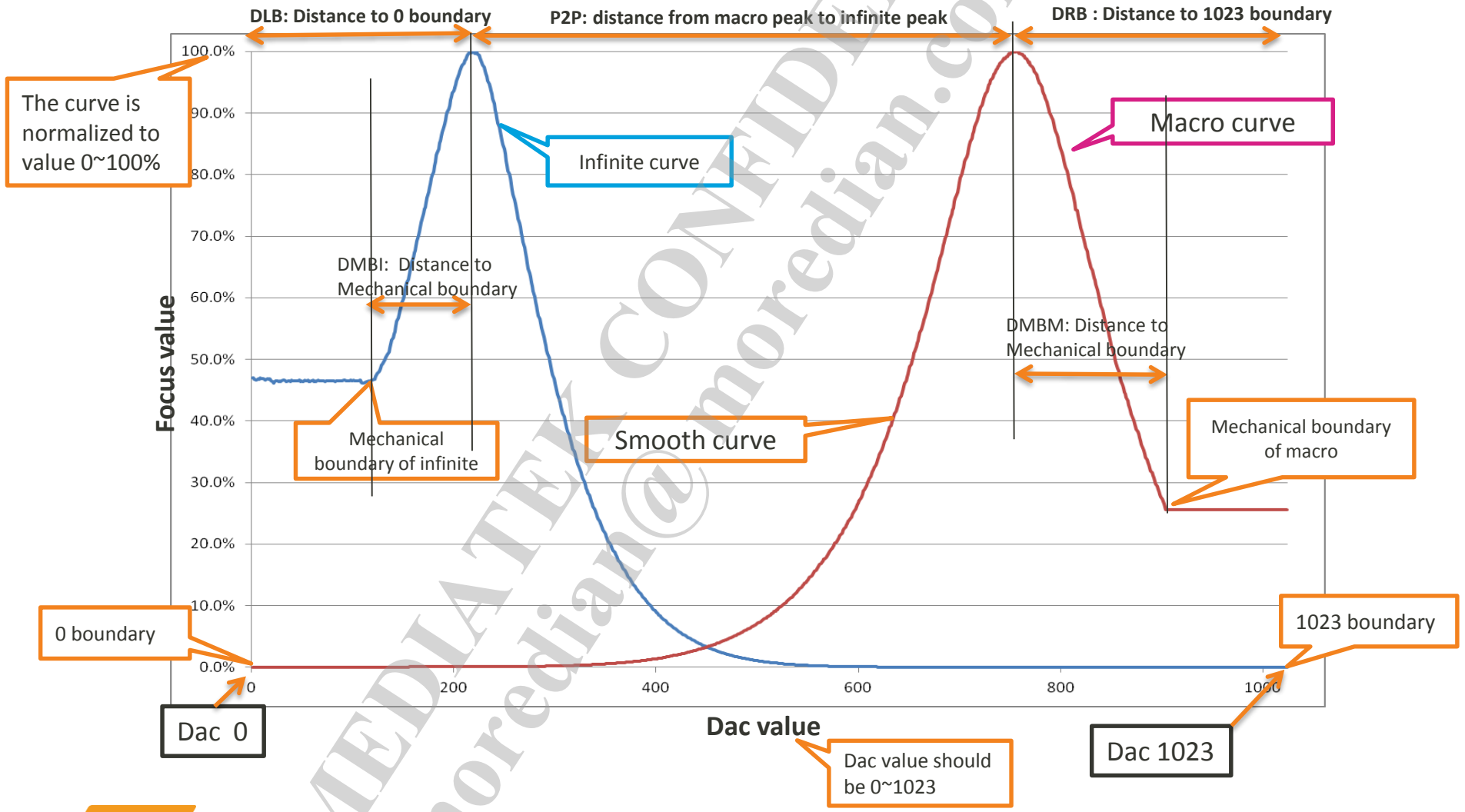
# 4. Mechanical check

- **Provide data: (reference to CameraModuleCheck_for_AutoFocus.xlsx)**
  - Provide the fine search curve (0~1023, 10bit dac), and confirm below items:
    1. Lens moving is smooth.
    2. Distances from infinite/macro peak to 0&1023 boundary.
    3. Distances from infinite/macro peak to mechanical boundary.



# 4. Mechanical check

- **Naming for curve parts:**



# 4. Mechanical check



- **Spec of curve parts:**

| | Item | Description | Spec |
|---|---|---|---|
| 1 | Smooth curve | Curve has no burr (as next slide Figure 1)<br>Curve is smooth(as next slide Figure 2) | Curve should be similar to last slide. |
| 2 | Distances to 0 &1023 boundaries | Peaks should have gap to 0 & 1023 boundaries to avoid AF miss focus at boundary. | DRB > (P2P)*20%<br>DLB > (P2P)*20% |
| 3 | Distance to mechanical boundary | Peaks should have gap mechanical boundary to avoid AF miss focus at boundary. | DMBM > (P2P)*10%<br>DMBI > (P2P)*10% |
| 4 | OTP Range | Inf./macro peak distance must have 10% digital code (10bit digital code, 0~1023 => 102) to make sure AF moving is precise. | P2P > 1023*10% |

**P2P: distance from macro peak to infinite peak**

**DMBI: Distance to Mechanical boundary (infinite)**

**DMBM: Distance to Mechanical boundary(macro)**

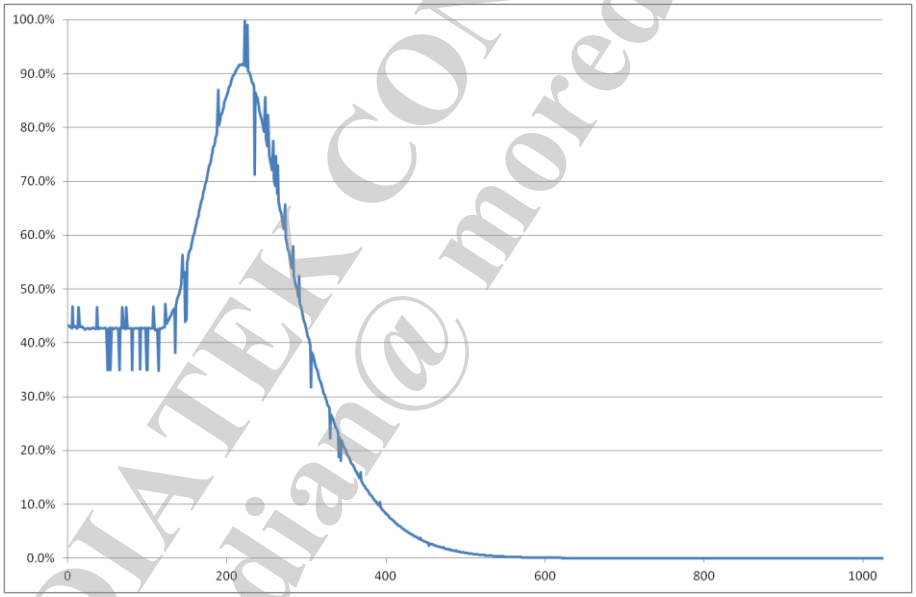
**DRB : Distance to 1023 boundary**

**DLB: Distance to 0 boundary**

# 4. Mechanical check

- **Fail case:**
  - Figure 1:

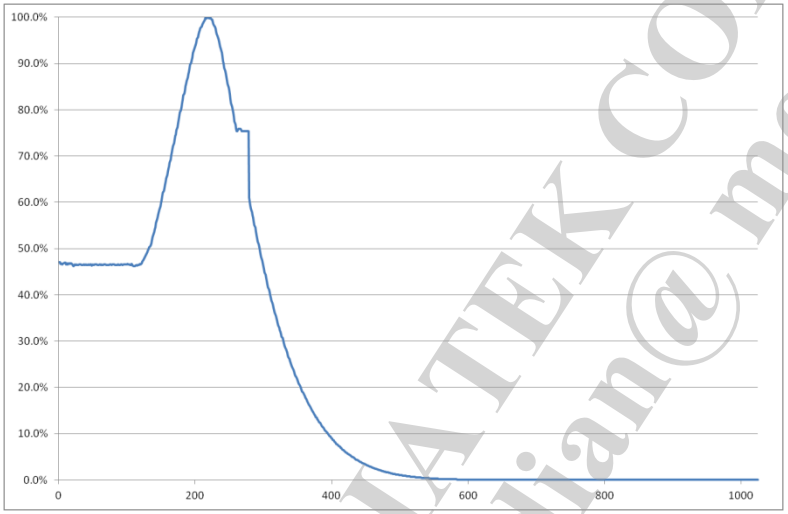
Curve with burr



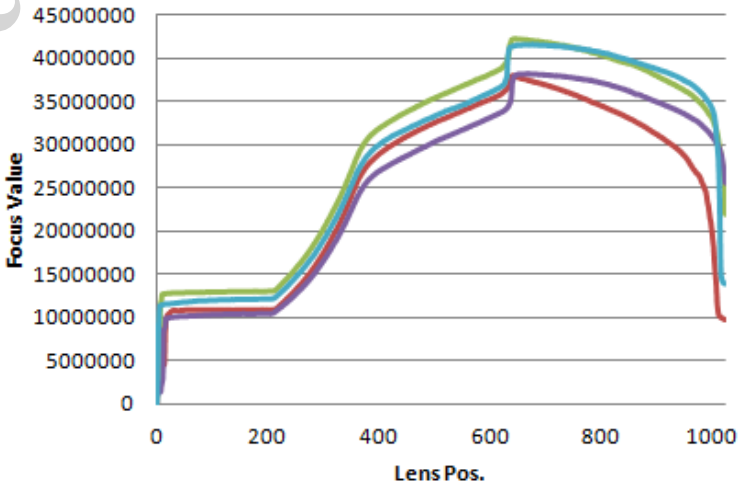
# 4. Mechanical check

- **Fail case:**
  - Figure 2:

**Curve is not smooth**




**Curve is different from example curve**



# Advance Check

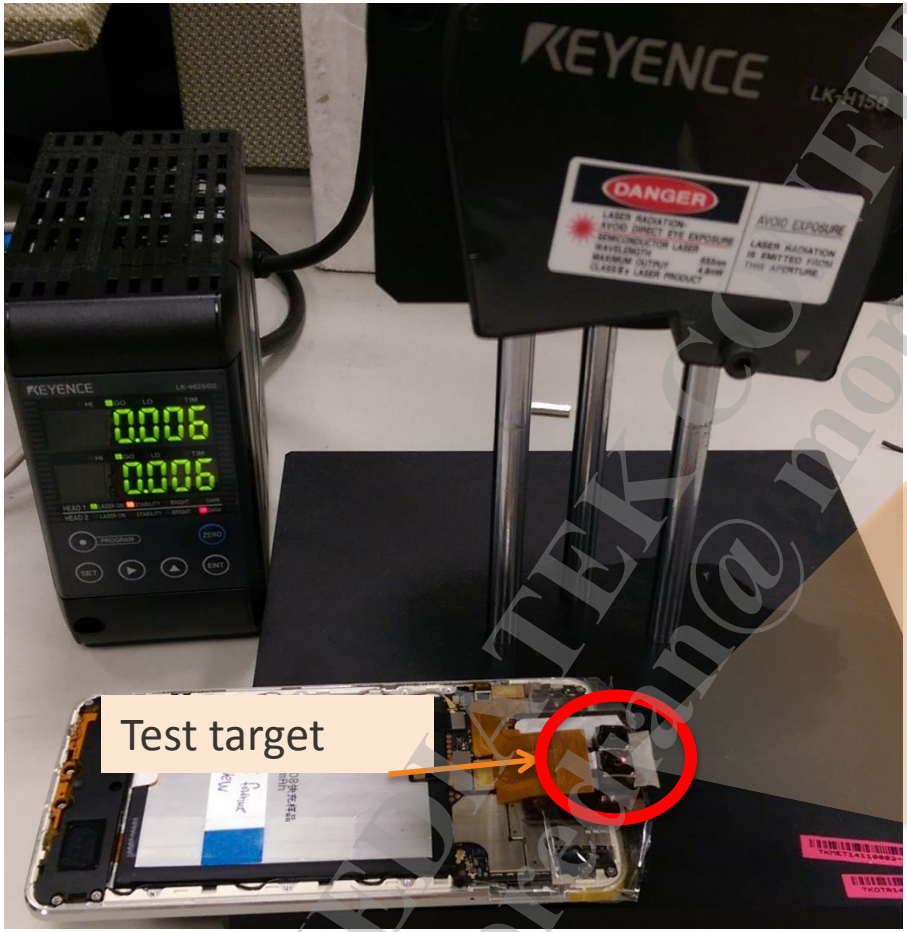
# Advance Check


- VCM quality check
  - -- Test Environment introduction
  1. Linearity Test
  2. Black lash/Hysteresis Test
  3. Accuracy Repeatability/Reliability Test
  4. Lens Posture/Gravity Test

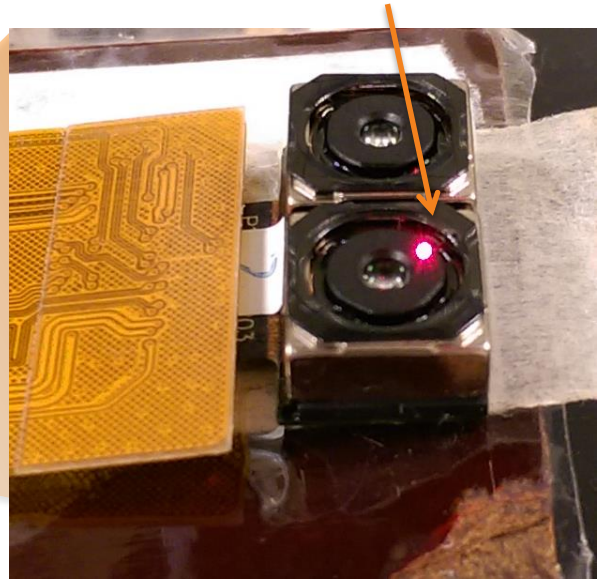
# Test Environment

- Test equipment:
  - Distance meter with measurement accuracy 1um.
  - Test target is camera module with movable lens unit. The camera module must have lens.
- Test setting:
  - Lens moving for full movable range.
  - Lens moving with specific lens position.
  - AF dac code must be 10bit 0~1023 domain. If not, driver must have a dac code mapping for it.
- Warming up Before Test:
  - Step1 --Warming up camera for 5 min. (keep camera power on 5min)
  - Step2– Trigger lens full scanning or moving, moving interval is 10 dac code (0,10,20,…1020)
- Output **(reference to CameraModuleCheck_for_AutoFocus.xlsx)**
  - Fill OTP inf./macro data to the excel.
  - Fill measured result to the excel.
  - The tool will calculated results and have a summary

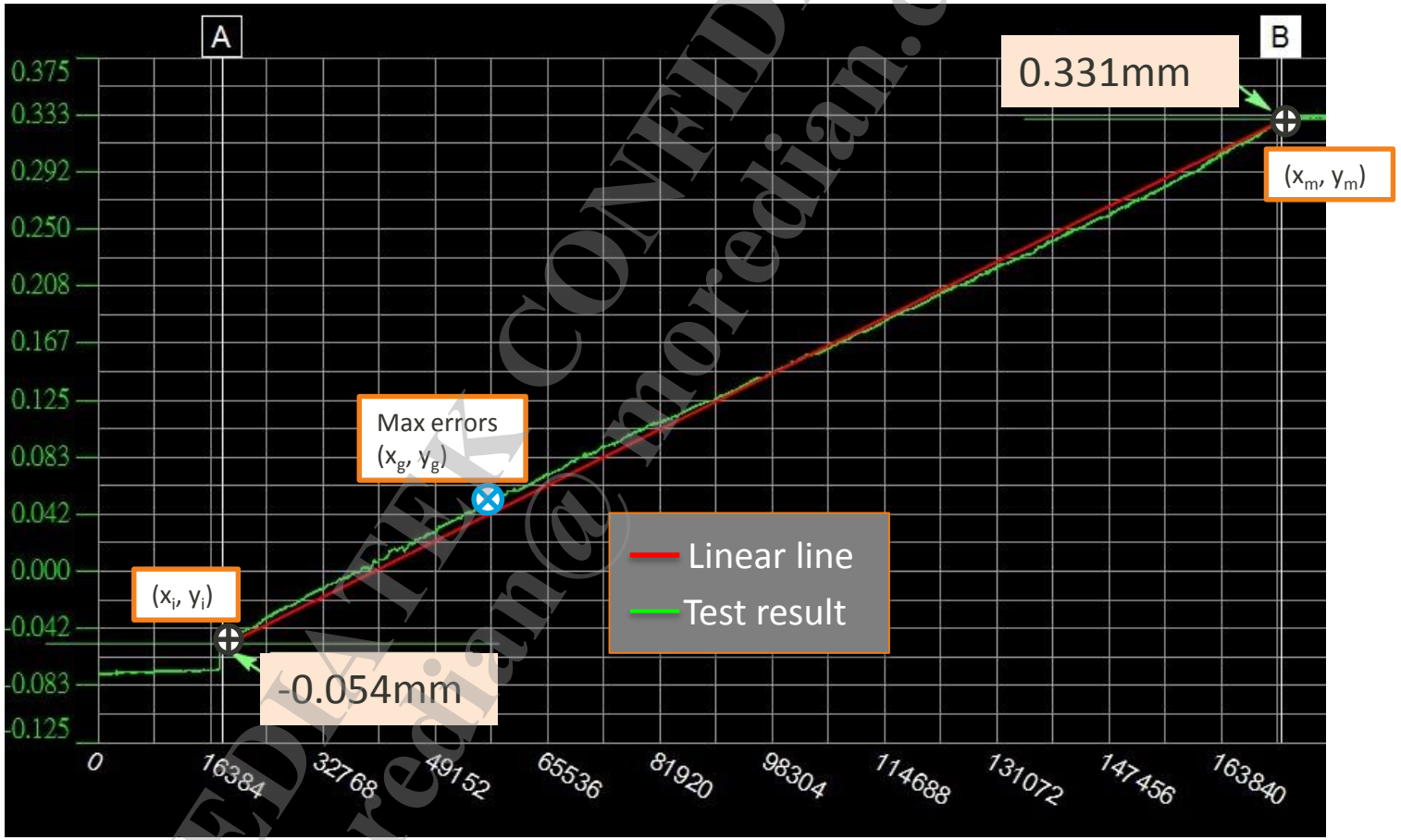
# Test Environment




Laser on lens



# Measurement Result



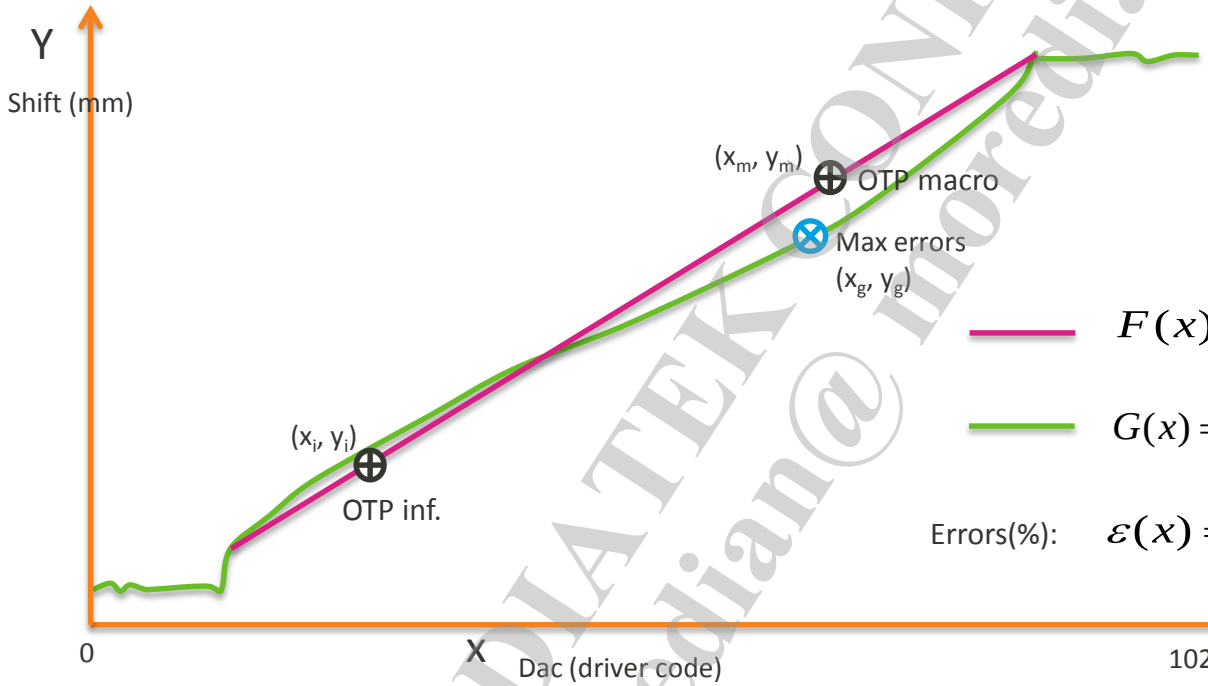
# LINEARITY TEST

# Linearity Test

- **Linearity Test**
  - Lens move from 0,10,20… to 1020 dac code
  - Calculate curve errors %.
- **Test Quantity**
  - 5 pcs module with lens on it.
  - Each module do 1 curve.
- **Calculation**
  - Show in next slide.
- **Test Spec**
  - Result max errors $\varepsilon(x) < 5\%$ (within OTP inf./macro range.)

# Calculation
# Linearity Test

- Find the max errors ε(x)




$$F(x) = y = \frac{y_m - y_i}{x_m - x_i} \cdot x + \frac{y_i x_m - x_i y_m}{x_m - x_i}$$

$$G(x) = \text{measured result}$$

Errors(%): $$\varepsilon(x) = \frac{|F(x) - G(x)|}{y_m - y_i}, \quad x = x_i \sim x_m$$

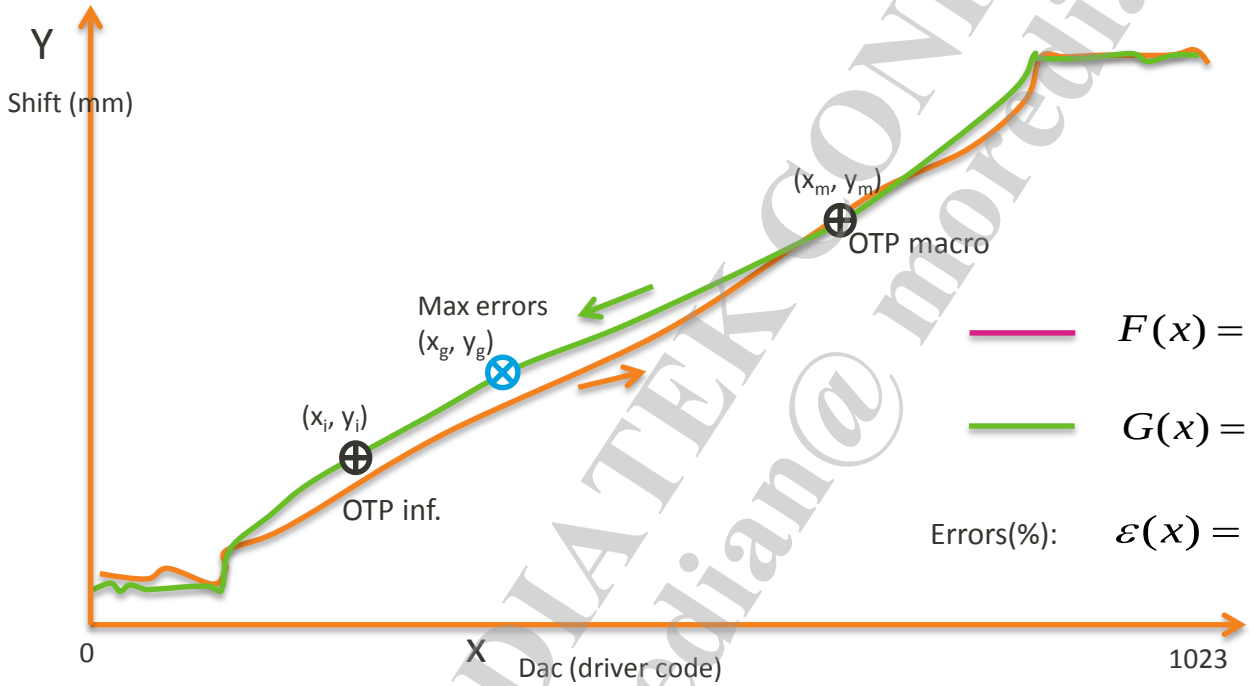
# BLACK LASH/HYSTERESIS TEST

# Black lash/Hysteresis Test

- **Black lash/Hysteresis Test**
  - Lens move from 0,10,20,… to 1020 dac code
  - Lens move from 1020,1010,… to 0 dac code
- **Test Quantity**
  - 5 pcs module with lens on it.
  - Each module do 2 curves (Moving forward/backward 2 directions).
- **Calculation**
  - Show in next slide.
- **Test Spec**
  - Result max errors $\varepsilon(x) < 5\%$ (within OTP inf./macro range.)

# Calculation
# Black lash/Hysteresis Test

- Find the max errors ε(x)




$F(x) = \text{measured result } 0 \sim 1023$

$G(x) = \text{measured result } 1023 \sim 0$

Errors(%): $\varepsilon(x) = \dfrac{|F(x) - G(x)|}{y_m - y_i}, \quad x = x_i \sim x_m$

# ACCURACY REPEATABILITY/RELIABILITY TEST

# Accuracy Repeatability/Reliability Test

- **Accuracy Repeatability/Reliability Test**
  - Lens move from p1,p2,p3,…to p10, and repeats 5 times per module.
  - Here {p1,p2,…p10} is defined as :
    - {OTPinf, OTPinf+interval, OTPinf+interval*2, OTPinf+interval*3, … OTPinf+interval*9}
    - interval = (OTPmacro – OTPinf)/9
  - Excel will auto generate the p1~p10 value after fill OTP data.
- **Test Quantity**
  - 5 pcs module with lens on it.
  - Each module repeats 5 Times.
- **Calculation**
  - Show in next slide.
- **Test Spec**
  - Result max errors ε(x) < 5%

# Calculation
# Accuracy Repeatability/Reliability Test

**(reference to CameraModuleCheck_for_AutoFocus.xlsx)**

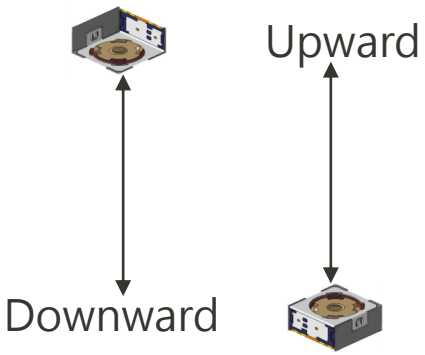
| 2. Fill the measurement position shift (um) according to the Dac | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Reliability Test** | | | | | | | | | | |
| **Module 1#** | **Fill the measurement position shift (um)** | | | | | | | | | |
| Dac | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 |
| | 215 | 259 | 303 | 347 | 391 | 435 | 479 | 523 | 567 | 611 |
| Test1 | 19.27 | 41.85 | 60.78 | 79.63 | 101 | 120.67 | 140.74 | 160.34 | 179.34 | 216.22 |
| Test2 | 19.72 | 40.45 | 60.23 | 79.3 | 101.31 | 120.92 | 141.69 | 158.87 | 179.17 | 216.47 |
| Test3 | 20.8 | 40.4 | 60.64 | 78.25 | 102.1 | 120.44 | 141.26 | 159.52 | 179.65 | 216.37 |
| Test4 | 19.62 | 39.82 | 60.93 | 80.1 | 100.68 | 120.06 | 142.01 | 160.42 | 179.68 | 216.89 |
| Test5 | 19.47 | 40.3 | 60.4 | 79.71 | 101.27 | 120.01 | 140.52 | 160.08 | 179.62 | 216.94 |

Errors(%): $$\varepsilon_{pn}(x) = \frac{Max_{pn} - Min_{pn}}{Average_{p_{10}} - Average_{p_1}} \times 100\%, n = 1...10$$

# LENS POSTURE/GRAVITY TEST

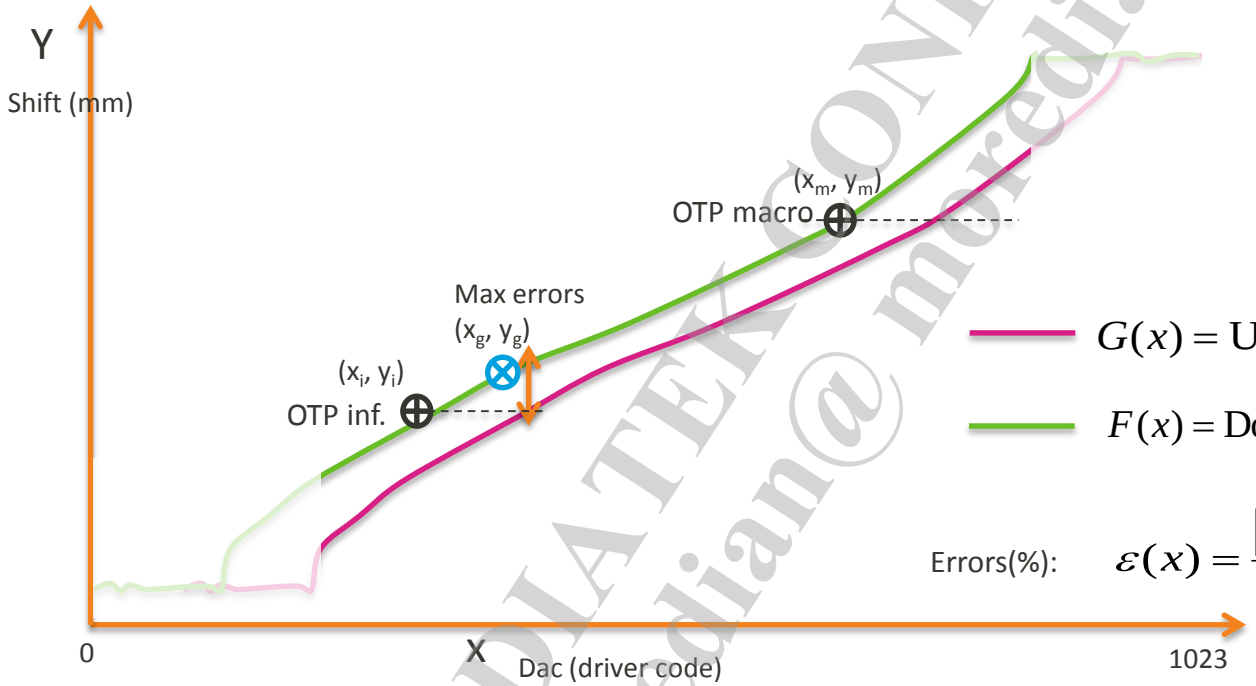
# Lens Posture/Gravity Test

- **Lens Posture/Gravity Test**
  - Set lens upward, and move from 0,10,20… to 1020 dac code
  - Set lens downward, and move from 0,10,20… to 1020 dac code.
  - Calculate curve errors %.
- **Test Quantity**
  - 5 pcs module with lens on it.
  - Each module results 2 curves (2 postures of upward/downward ).
- **Calculation**
  - Show in next 2 slides.
- **Test Spec**
  - Posture compensated max. ε(x) < 5%
  - Calculate by the excel.



# Calculation
# Lens Posture/Gravity Test

- Find the max errors ε(x)




$G(x) = \text{Upward measured result}$

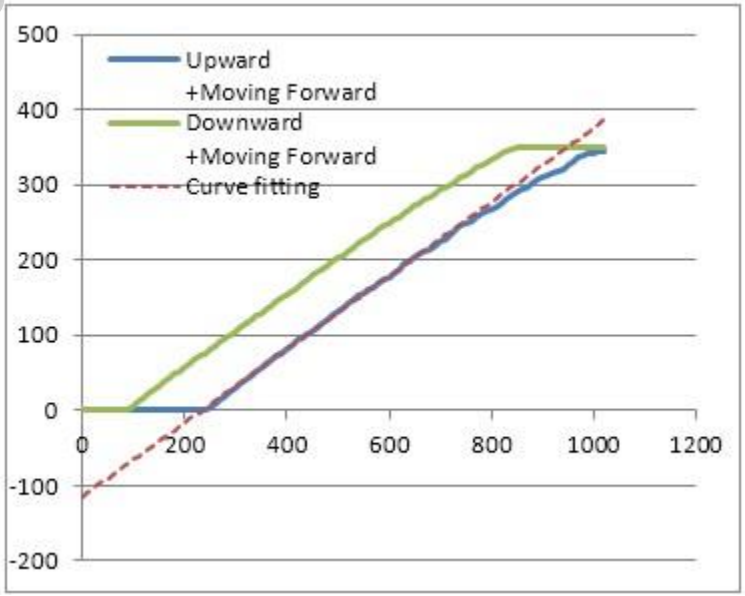
$F(x) = \text{Downward measured result}$

Errors(%): $\varepsilon(x) = \dfrac{|F(x) - G(x)|}{y_m - y_i}, \quad x = x_i \sim x_m$

# Calculation
# Lens Posture/Gravity Test

- Calculation:
  - The excel “CameraModuleCheck_for_AutoFocus.xlsx“ can do regression automatically, and calculate posture result with/without compensated.

| Lens Posture Test | w/o compensation | | w/ compensation | |
|---|---|---|---|---|
| | 40.80% | | 4.79% | |
| | 39.167173 | Dac | 4.5988375 | dac |



# Summary

- A summary report will show in the excel “summary page”
- Please provide the result excel file to us.


*everyday genius*

# Dual Camera Module Reference Notes

Bayer + Bayer | Bayer + Mono | Wide + Tele

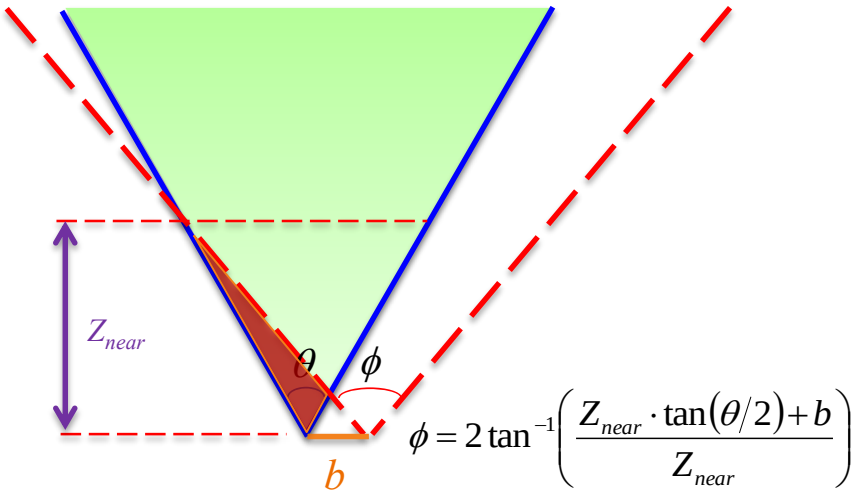
2017/08/22

* This document is for reference design. For customized module configuration, please consult with our contact window.

# BAYER (13M) + BAYER (5M) STEREO MODULE

# Notes

- Basic Requirement
  - Fixed/Autofocus module for main camera
  - Fixed focus for auxiliary camera
  - Less optical distortion to achieve better depth quality
    - Optical lens distortion < 2% (recommend < 1.5%)
  - Identical F. no
  - ~~Closed-loop autofocus module~~
- Fixed Focus Distance
  - Back stereo camera: hyper-focus
  - Front stereo camera: 30-40 cm (refer to the lens SPEC.)
- FOV & Baseline
  - Hor./Ver. FOV of auxiliary camera covers Hor./Ver. FOV of main camera according to determined baseline (*b*)
  - Shorter baseline (the shorter, the better)
  - If auxiliary camera can't cover main camera, then main camera must be cropped



# Example of Stereo Module

| | 13M | 5M |
|---|---|---|
| Sensor | IMX258-0AUH5-C | S5K5E2 |
| Lens | Largan 50065B8 | Largan 40120A1 |
| FOV | 66.2 (H) \| 51.6 (V) | 72.2 (H) \| 57.3 (V) |
| Optical distortion | < 2.0% | < 2.0% |
| F. no | 2.0 ± 5% | 2.0 ± 5% |
| Baseline | 12.0 mm | |

# Estimated Depth Accuracy

- *z*-table mapping
  - Assume stereo module is ideal and ±3 pix uncertainty due to the manufacture error of stereo module and limitation of matching algorithm

| 1920x1080 \| 1.2cm | | | | |
|---|---|---|---|---|
| Z (cm) | disp (pix) | $Z_{min}$ (cm) | $Z_{max}$ (cm) | Err (%) |
| 10 | 186.9 | 9.84 | 10.16 | 1.63 |
| 30 | 62.3 | 28.62 | 31.52 | 5.06 |
| 60 | 31.1 | 54.73 | 66.39 | 10.66 |
| 100 | 18.7 | 86.17 | 119.12 | 19.12 |
| 200 | 9.3 | 151.4 | 294.57 | 47.29 |
| 400 | 4.7 | 243.59 | 1117.6 | 179.40 |

  - Example.
    - For the case that object distance at 100cm, the estimation uncertainty may range between [86.17, 119.12] cm, so that the object located closer than 86.17.0cm and farther than 119.12cm can be separated

# Causes of Disparity Uncertainty

- Manufacture geometric error in stereo module
  - Stereo geometry
  - Lens distortion
- Image quality
  - Intensity difference between two input images
  - Image noises
  - Focus scaling effect
  - Focus blur
- Matching algorithms

# BAYER (13M) + MONO (13M) STEREO MODULE

# Notes

- Basic requirement
  - The same lens for the two cameras
  - The same closed-loop autofocus module for the two cameras
  - Shorter baseline  (the shorter, the better)
  - Avoid magnetic interference between two autofocus motors due to short baseline
  - Less optical distortion to achieve better image and depth quality
    - Optical lens distortion < 2% (recommend < 1.5%)

# Driver-Ready Camera Module

| | 13M (Bayer) | 13M (Mono) |
|---|---|---|
| Sensor | Sony IMX-258 | Sony IMX-258BW |
| Lens | 50016A21 | 50016A21 |
| FOV | 63.2 (H) \| 75.0 (D) | 63.2 (H) \| 75.0 (D) |
| Optical distortion | < 2.0% | < 2.0% |
| F. no | 2.0 ± 5% | 2.0 ± 5% |
| Baseline | 9.8 mm | |
| VCM | TVC-651ABM, Close Loop | TVC-651ABM, Close Loop |

# Estimated Depth Accuracy

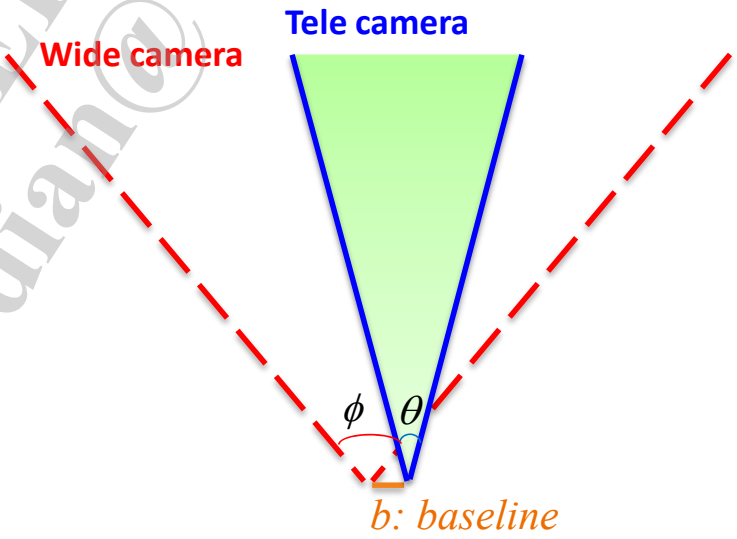
- *z*-table mapping
  - Assume stereo module is ideal and ±3 pix uncertainty due to the manufacture error of stereo module and limitation of matching algorithm

| 1920x1080 \| 0.98 cm | | | | |
|---|---|---|---|---|
| Z (cm) | disp (pix) | $Z_{min}$ (cm) | $Z_{max}$ (cm) | Err (%) |
| 10 | 152.9 | 9.81 | 10.20 | 2.00 |
| 30 | 51.0 | 28.33 | 31.88 | 6.25 |
| 60 | 25.5 | 53.68 | 68.00 | 13.34 |
| 100 | 15.3 | 83.60 | 124.41 | 24.41 |
| 200 | 7.6 | 143.64 | 329.14 | 64.57 |
| 400 | 3.8 | 224.13 | 1857.87 | 364.47 |

# WIDE (12M) + TELE (12M) STEREO MODULE

# Notes

- Basic requirement
  - Fixed/Autofocus module for wide camera
  - Fixed/Autofocus module for tele camera
  - Closed loop autofocus module is required
  - The same closed loop autofocus module for the two cameras
  - Less optical distortion
  - FOV of wide camera covers FOV of tele camera
  - Parallel Axis
  - Shorter baseline (the shorter, the better)
  - Avoid magnetic interference between two autofocus motors due to short baseline



# An example

| | 13M (Wide) | 13M (Tele) |
|---|---|---|
| Sensor | Samsung 2M8 | Samsung 3M3 |
| Lens | Largan 9684 | Largan 60018 |
| FOV | 83.0 | 47.3 |
| Optical distortion | < 2.0% | < 2.0% |
| F. no | 2.0 ± 5% | 2.6 ± 5% |
| Baseline | 8 mm | |

| | | |
|---|---|---|
| VCM | Close loop AF | Close loop AF |

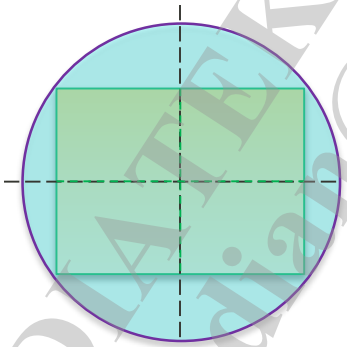
Stereo Camera System Hardware Setting

# STEREO MODULE ERROR TOLERANCE

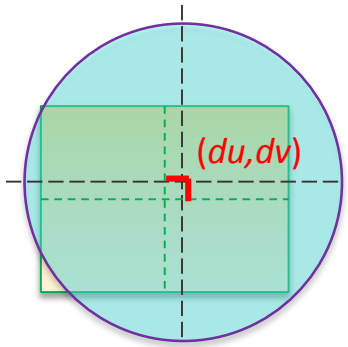
* The following error tolerance need to be guaranteed after external force during assembly process and/or drop tests.

# Single Camera Module Requirement

| | Required Error Tolerances | Note |
|---|---|---|
| ( $\mu$, $\emptyset$, $\vartheta$ )<br>(rotation angle along *Z,Y,X*-axis) | - | Trivial & Unmeasurable |
| Optic Center, X-Axis (+/-) | **10 pixel** | under image scale of 1920*1440 |
| Optic Center, Y-Axis (+/-) | **10 pixel** | under image scale of 1920*1440 |
| Z-Axis (+/-) | - | Trivial |



*ideal*




*translation*

# Single Camera Module Requirement - An Example

| Sensor | IMX-258 (13M) | 5E2 (5M) |
|---|---|---|
| Image size | 4208*3120 | 2560*1920 |
| Pixel size ( um ) | 1.12 | 1.12 |
| OC tolerance ( pixel ) | ±22 | ±13 |
| OC tolerance ( mm ) | ±0.025 | ±0.015 |

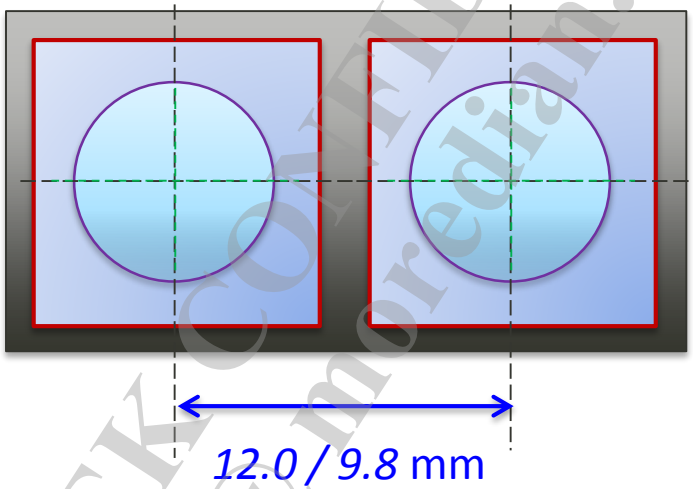
10(px)/1920*4208 ≈ 22(px)

22(px)*1.12 ≈ 25(um) = 0.025(mm)

10(px)/1920*2560 ≈ 13(px)

13(px)*1.12 ≈ 15(um) = 0.015(mm)

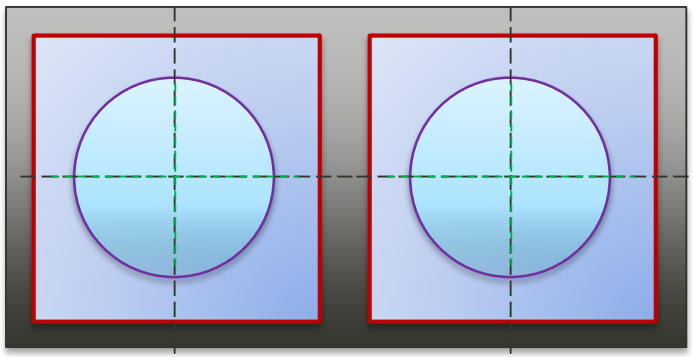
# Baseline



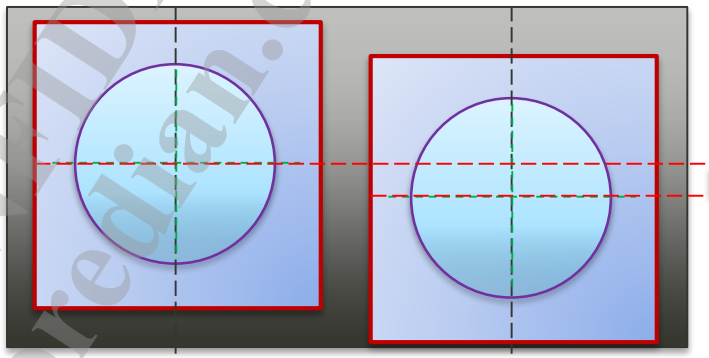

Distance between two cameras

- Reference: *12.0* mm ( 13M+5M ) *9.8* mm ( 13M + 13M )
- Error tolerance: ± *0.1* mm

# Vertical Alignment Error



*ideal*

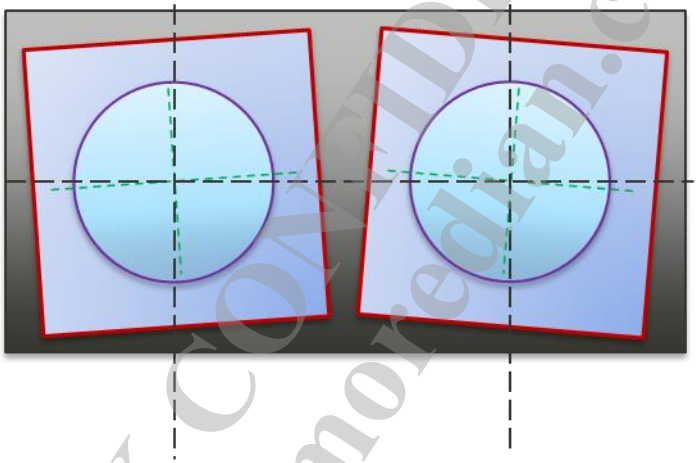



*practical*

Vertical alignment

- Reference: *0.0 mm*
- Error tolerance: : ± *0.1* mm

# Rotational Error



Roll angle error

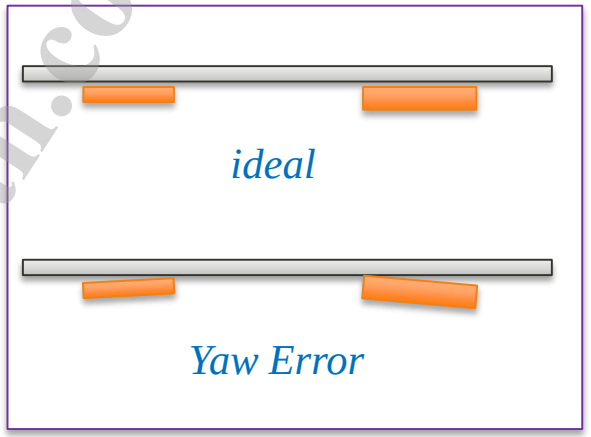
- Reference: *0.0°*
- Error tolerance: : *±1.5°* (*1.0°* )

IQC threshold: *1.0°*
After assembly and drop tests: *1.5°*

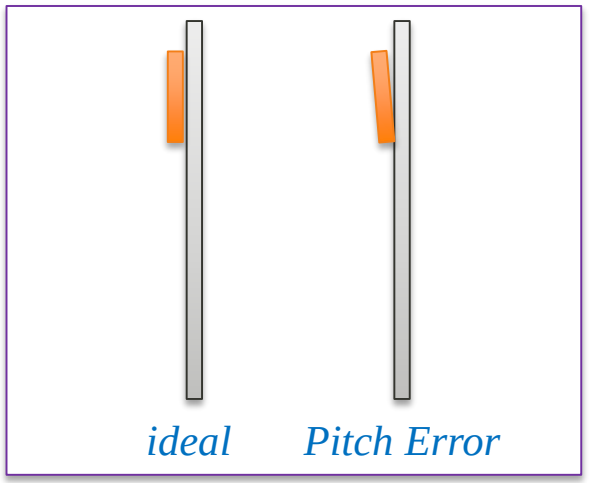
The rotation angles indicate the relative rotation from the main camera to the sub camera.

# Tilt Error

Yaw angle error
- Reference: *0.0°*
- Error tolerance: : *±1.5°* ( ±1.0° )




Pitch angle error
- Reference: *0.0°*
- Error tolerance: : *±1.5°* ( ±1.0° )




IQC threshold: *1.0°*
After assembly and drop tests: *1.5°*

# Brief Summary

The error tolerance specification for module vendor OQC

| Baseline | | Optical Axis | | | Optical Center | |
|---|---|---|---|---|---|---|
| X-Shift | Y-Shift | $R_x$ - tilt | $R_y$ - tilt | $R_z$ – rot | OC - X | OC - Y |
| ±0.1mm | ±0.1mm | ±1.0° | ±1.0° | ±1.0° | ±10 pixel | ±10 pixel |

under image size: 1920*1440

The error tolerance after assembly and drop tests

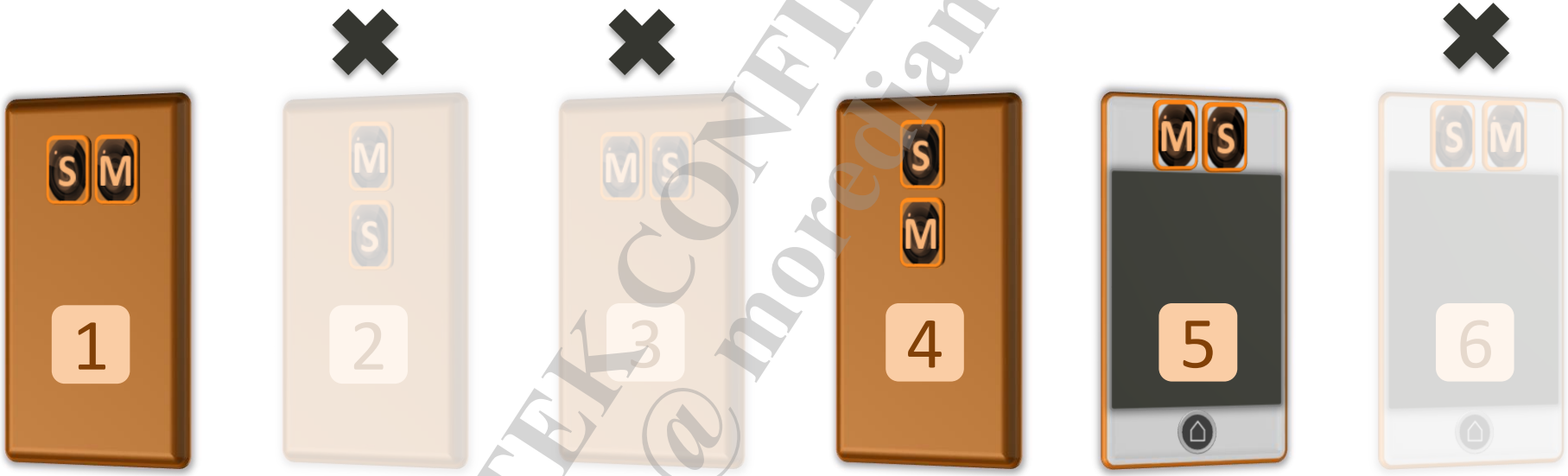
| Baseline | | Optical Axis | | | Optical Center | |
|---|---|---|---|---|---|---|
| X-Shift | Y-Shift | $R_x$ - tilt | $R_y$ - tilt | $R_z$ – rot | OC - X | OC - Y |
| ±0.1mm | ±0.1mm | ±1.5° | ±1.5° | ±1.5° | ±10 pixel | ±10 pixel |

under image size: 1920*1440

# Camera Orientation

## B+B / B+M

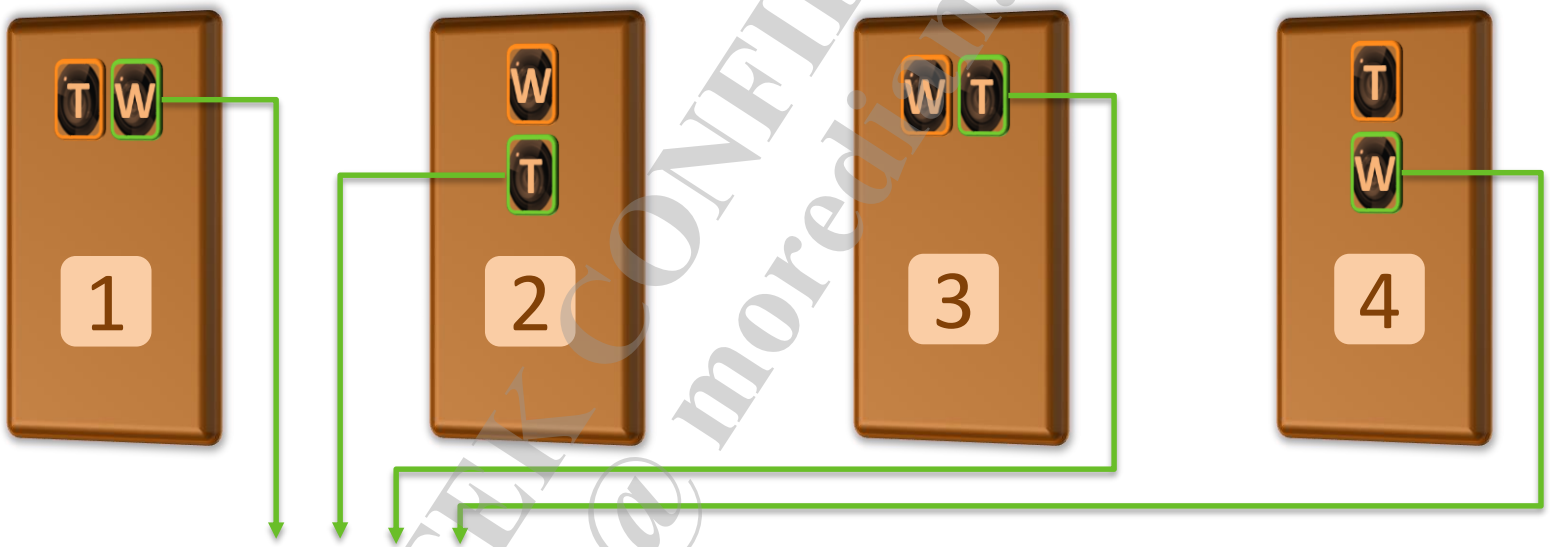
There are only six types of camera orientation under the android rules




- Recommended for Bokeh applications :
  - Rear camera, configuration #1 and #4
  - Front camera, configuration #5

# Camera Orientation

**W+T**




- Major camera for Bokeh applications :
  - Wide: configuration #1 and #4
  - Tele: configuration #2 and #3

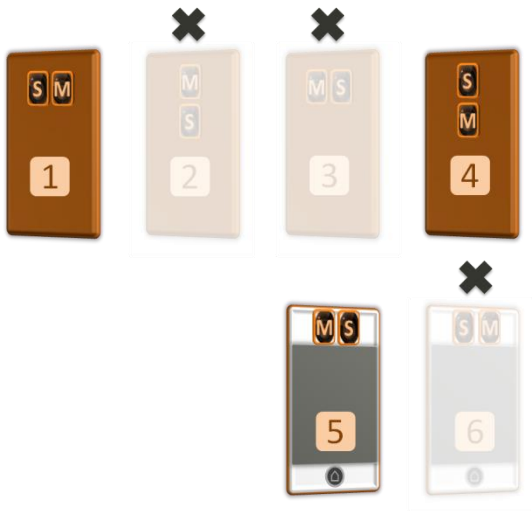
# Required Information

1. Detailed lens spec of both camera module, respectively
2. Detailed sensor spec of both camera module, respectively
3. Simulation data of lens distortion curve ( i.e. simulation data of lens distortion curve with 10.0 cm interval from micro to infinite, say { 10.0, 20.0, …, 200.0; 300.0; 400.0, 500.0, 750.0, 1000.0 } cm.
4. CRA curve fitness between lens and sensor, for both cameras, respectively
5. Design layout of the stereo camera module
6. [for B+M] Spectrum response of the color filters between mono sensor and color sensor, in terms of { R, G, B, mono} channel

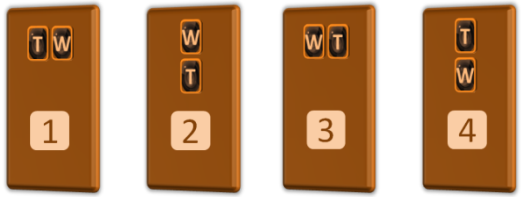
# Configuration Table

| Customer_Vendor_MT6797_13M+_13M | | | |
|---|---|---|---|
| 0 | Module type | B+B / B+M / W+T | |
| 1 | Layout configuration ( please refer to the right figure) | 1 - 6 | |
| 2 | Baseline (mm) | | |
| 3 | Main camera sensor – model | | |
| 4 | Main camera sensor - Raw image size (w,h) | | |
| 5 | Main camera sensor - Raw image - Bayer pattern | | |
| 6 | Main camera lens – model | | |
| 7 | Main camera lens - FOV (horizontal, vertical) | | |
| 8 | Main camera - RI (Relative Illumination) % | | |
| 9 | Main camera VCM – model | | |
| 10 | Main camera fix focus distance | | |
| 11 | Sub camera sensor – model | | |
| 12 | Sub camera sensor - Raw image size (w,h) | | |
| 13 | Sub camera sensor - Raw image - Bayer pattern | | |
| 14 | Sub camera lens – model | | |
| 15 | Sub camera lens - FOV (horizontal, vertical) | | |
| 16 | Sub camera - RI (Relative Illumination) % | | |
| 17 | Sub camera VCM – model | | |
| 18 | Sub camera fix focus distance | | |

B+B / B+M




W+T

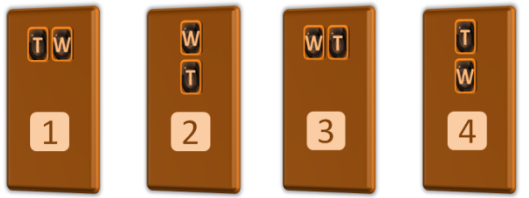


# Example: Configuration Table

| Customer_Vendor_MT6797_13M+_13M | | | |
|---|---|---|---|
| 0 | Module type | B+B | |
| 1 | Layout configuration ( please refer to the right figure) | 1 | |
| 2 | Baseline (mm) | 9.8cm | |
| 3 | Main camera sensor – model | IMX214 | |
| 4 | Main camera sensor - Raw image size (w,h) | 4208 | 3120 |
| 5 | Main camera sensor - Raw image - Bayer pattern | RGGB | |
| 6 | Main camera lens – model | Largan 50016A | |
| 7 | Main camera lens - FOV (horizontal, vertical) | 63.3 | 49.1 |
| 8 | Main camera - RI (Relative Illumination) % | 36.1 | |
| 9 | Main camera VCM – model | TVC-651ABF | |
| 10 | Main camera fix focus distance | 40cm | |
| 11 | Sub camera sensor – model | IMX214 | |
| 12 | Sub camera sensor - Raw image size (w,h) | 4208 | 3120 |
| 13 | Sub camera sensor - Raw image - Bayer pattern | MONO | |
| 14 | Sub camera lens – model | Largan 50016A | |
| 15 | Sub camera lens - FOV (horizontal, vertical) | 63.3 | 49.1 |
| 16 | Sub camera - RI (Relative Illumination) % | 36.1 | |
| 17 | Sub camera VCM – model | TVC-651ABF | |
| 18 | Sub camera fix focus distance | 40cm | |

B+B / B+M


W+T




everyday genius

CONFIDENTIAL B

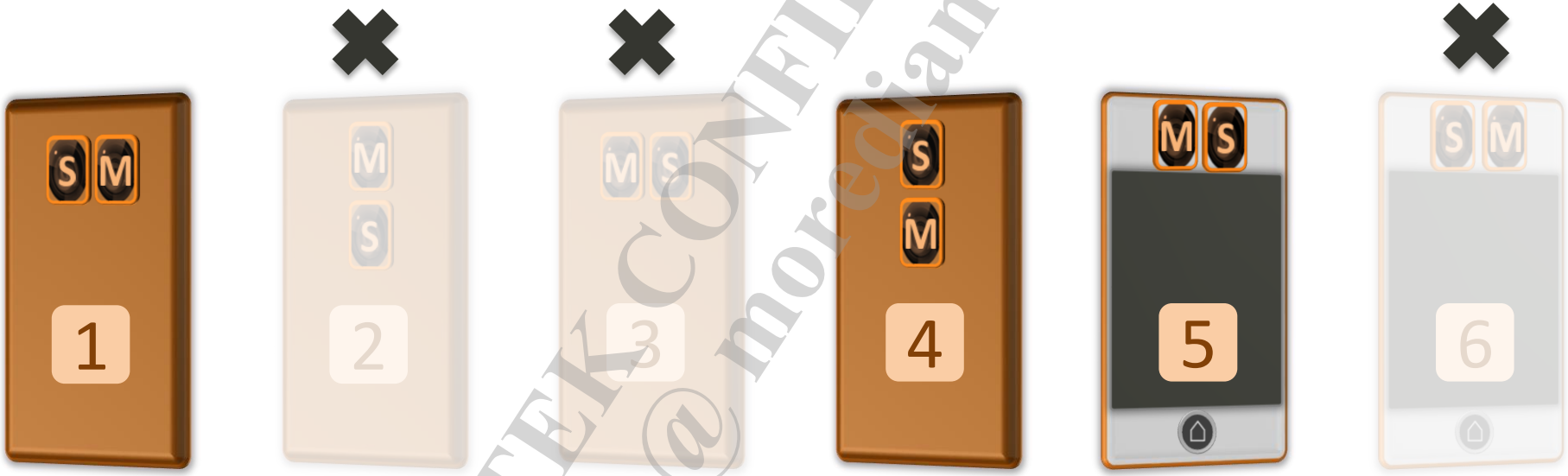
# Module Layout Guidance

## B+B / B+M / W+T

# Camera Orientation

## B+B / B+M

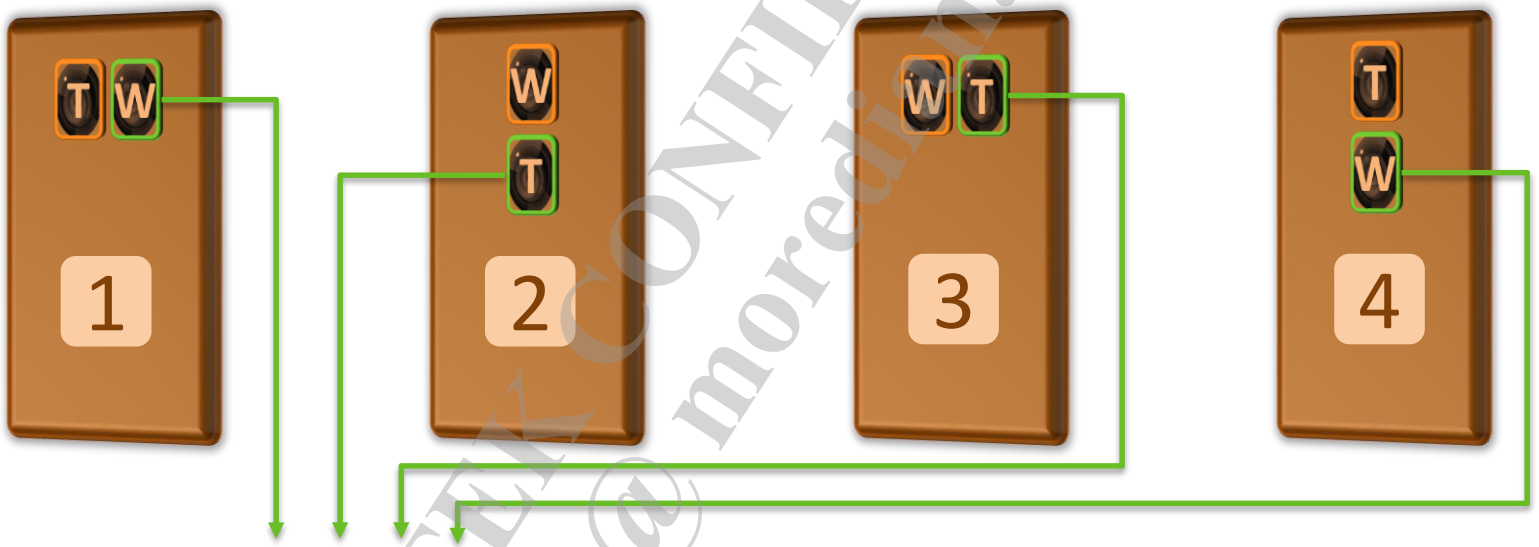
There are only six types of camera orientation under the android rules




- Recommended for Bokeh applications :
  - Rear camera, configuration #1 and #4
  - Front camera, configuration #5

# Camera Orientation

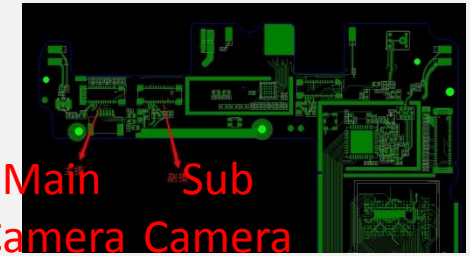
**W+T**




- Major camera for Bokeh applications :
  - Wide: configuration #1 and #4
  - Tele: configuration #2 and #3

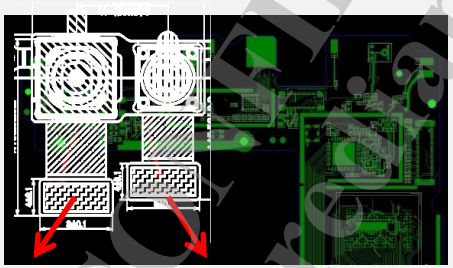
# Phone Layout & Module Layout

Phone Layout

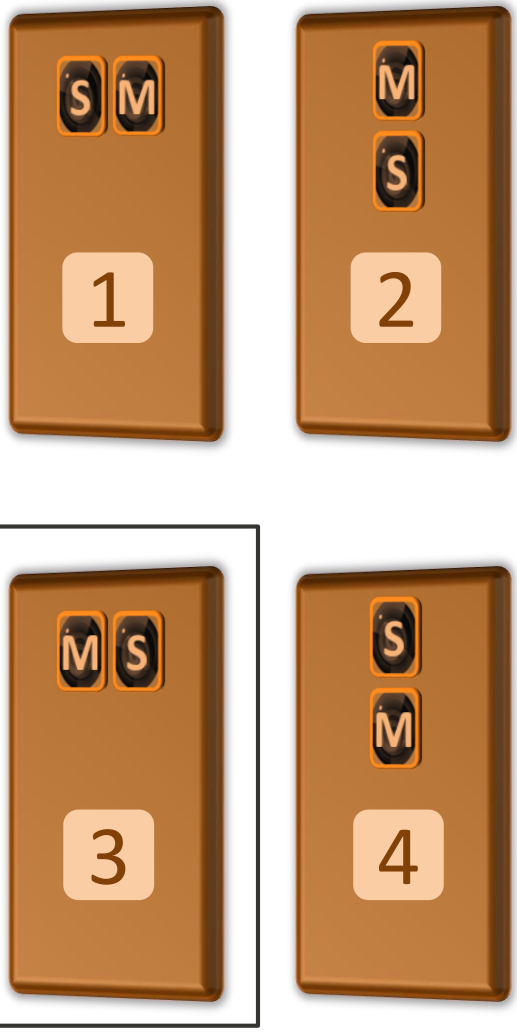



Top view

Phone Layout with module



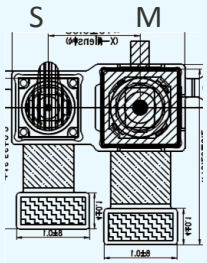

Top view



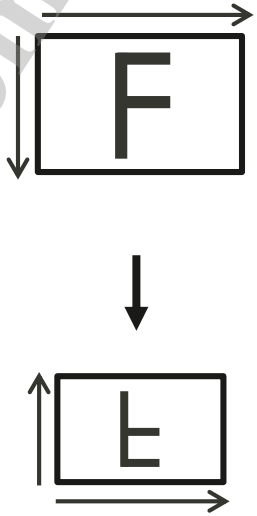
# REAR CAMERA

# Type 1


Top view

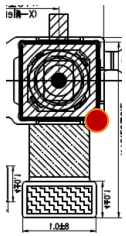
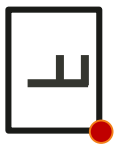
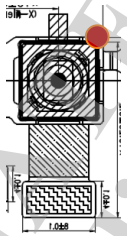
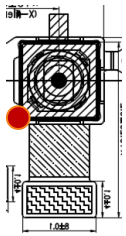
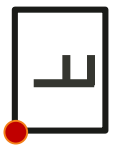
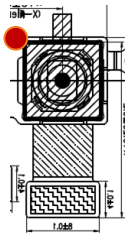



Front of the sensor


Real object (image成像)

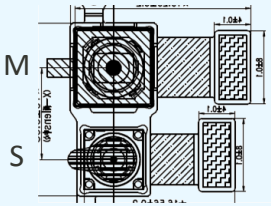
Sensor成像

| sensor | sensor 成像 | Flip | Mirror |
|---|---|---|---|
|  |  | X | X |
|  |  | X | O |
|  |  | O | X |
|  |  | O | O |

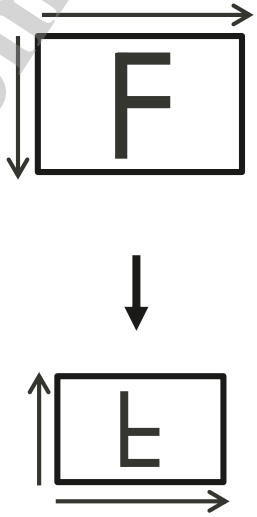
First pixel position

# Type 2


Top view

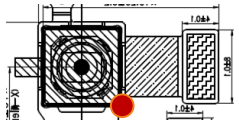
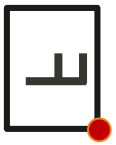
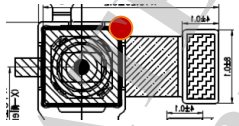
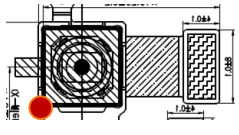
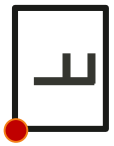
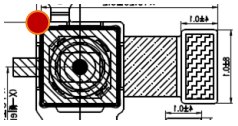
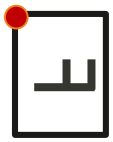



Front of the sensor


Real object (image成像)

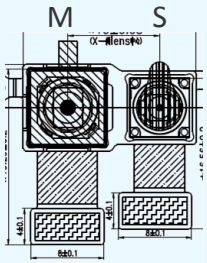
Sensor成像

| sensor | sensor 成像 | Flip | Mirror |
|---|---|---|---|
|  |  | X | X |
|  |  | X | O |
|  |  | O | X |
|  |  | O | O |

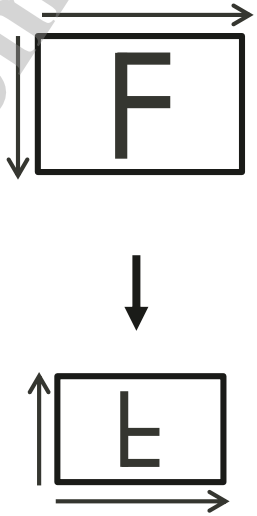
● First pixel position

# Type 3


Top view

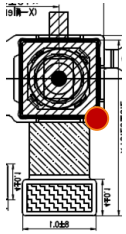
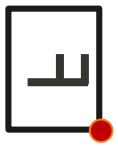
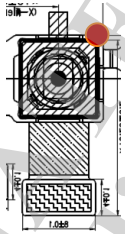
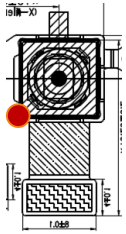
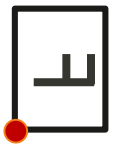
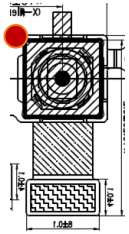



Front of the sensor

Real object (image成像)

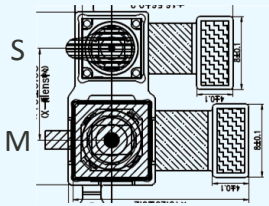
Sensor成像

| sensor | sensor 成像 | Flip | Mirror |
|---|---|---|---|
|  |  | X | X |
|  |  | X | O |
|  |  | O | X |
|  |  | O | O |

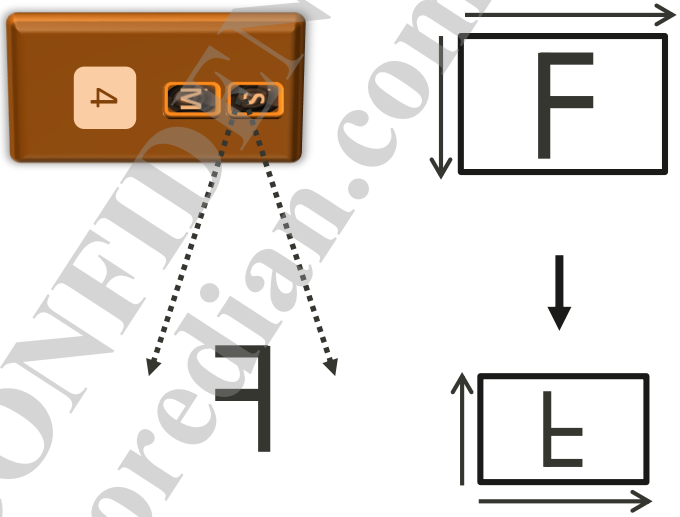
● First pixel position

# Type 4


Top view

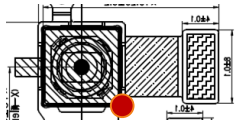
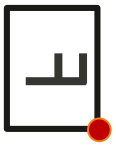


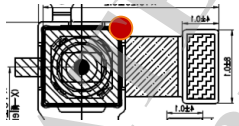
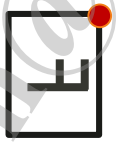

Front of the sensor

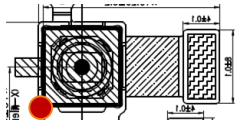
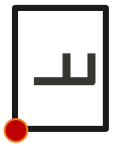


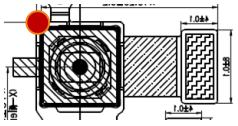
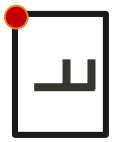

Real object (image成像)

Sensor成像

| sensor | sensor 成像 | Flip | Mirror |
|---|---|---|---|
|  |  | X | X |

| sensor | sensor 成像 | Flip | Mirror |
|---|---|---|---|
|  |  | X | O |

| sensor | sensor 成像 | Flip | Mirror |
|---|---|---|---|
|  |  | O | X |

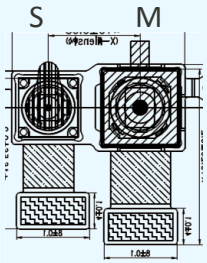
| sensor | sensor 成像 | Flip | Mirror |
|---|---|---|---|
|  |  | O | O |

● First pixel position

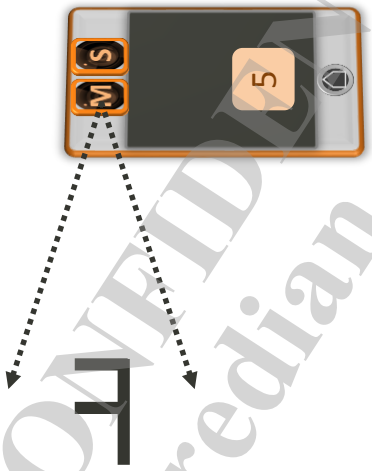
# FRONT CAMERA

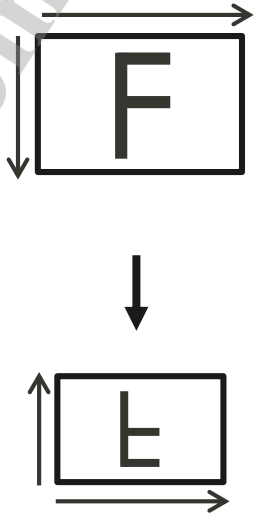
# Type 5


Top view



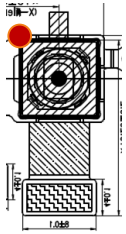
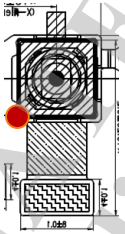
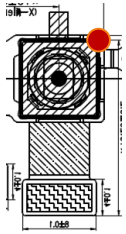
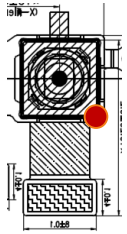
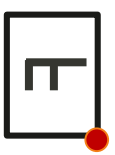

Front of the sensor



Real object (image成像)

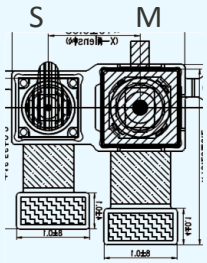
Sensor成像

| sensor | sensor 成像 | Flip | Mirror |
|---|---|---|---|
|  |  | x | x |
|  |  | x | o |
|  |  | o | x |
|  |  | o | o |

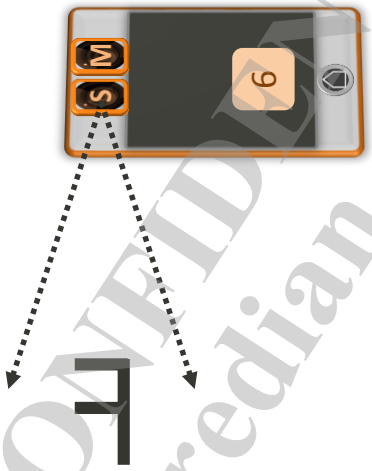
● First pixel position

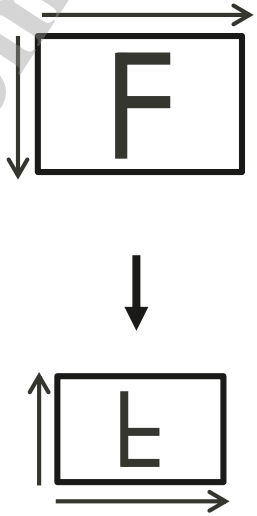
# Type 6

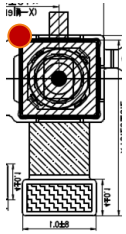
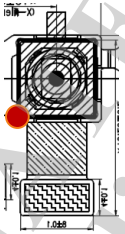
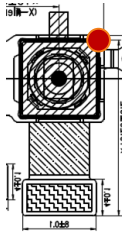
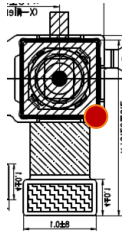
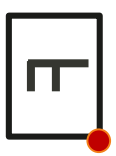

Top view




Front of the sensor




| sensor | sensor 成像 | Flip | Mirror |
|---|---|---|---|
|  |  | X | X |
|  |  | X | O |
|  |  | O | X |
|  |  | O | O |

● First pixel position

# II. Module Select

CONFIDENTIAL B

# Golden Module Selection

Version: V1.1
Release date: 2017-06-27

# Document Revision history

| Revision | Date | Description |
|---|---|---|
| V1.0 | 2016-05-17 | • First version |
| V1.1 | 2016-06-27 | • Update ISP part for generic estimation |
| | | |
| | | |
| | | |

# Outline

1. AE
2. AWB
3. AF
    1. OTP Accuracy
    2. Lens tilt
4. LSC
5. ISP

# Golden Module Selection Purpose

# Golden Module Selection Purpose

- In order to have good camera module sample for camera quality tuning, this document provide methods for select golden modules.
- With this document, vendor or customer can execute camera tuning with correct golden sample by themselves.

# Golden Module Selection for AE

# Golden Module Selection for AE

- Currently, AE don’t need to do golden selection, skip.

# Golden Module Selection for AWB

# Golden Module Selection for AWB

- **Module amount:**
  - > 10 PCS
- **Test environment:** (no need)
- **Collect data:**
  - Get all modules OTP AWB calibration value (R, GR, GB, &B values).
  - Get OTP AWB golden value (all module should be the same)

- **Choice rule:**
  - Criteria : The difference of R/G and B/G between golden OTP is less than 1%.
  - The module satisfied the criteria can be taken as golden sample.

$$(\Delta R/G) = (\text{Golden\_OTP}(R/G) - \text{UNIT\_OTP}(R/G))^2$$
$$(\Delta B/G) = (\text{Golden\_OTP}(B/G) - \text{UINT\_OTP}(B/G))^2$$
$$\text{Whrere } G = (G_b + G_r)/2$$
$$\Delta E = \sqrt{(\Delta R/G)_k + (\Delta B/G)_k} < 1\%$$

# Golden Module Selection for AWB

- Q&A
  - Q1: How to check if the AWB OTP data is OK for camera?
  - A1:  for the unit and golden R/Gr/Gb/B, should satisfy..
    - unit & golden Gb & Gr value should between 140 and 190.
    - ABS[(R/G_Unit − R/G_golden) / (R/G_golden)] < 10%
    - ABS[(B/G_Unit − B/G_golden) / (B/G_golden)] < 10%

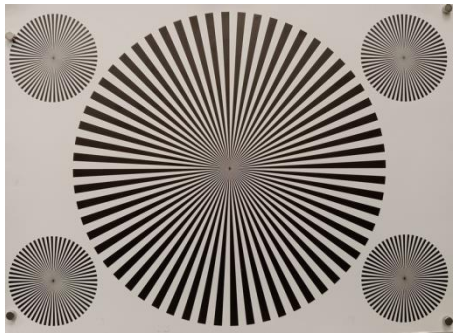
# Golden Module Selection for AF

# Golden Module Selection for AF

- **AF Golden needs to check 2 items:**
  - **OTP accuracy:**
    - Find the **limit** sample for tuning, and AF table can cover all modules.
  - **Lens Tilt:**
    - Lens tilt affects all sharpness related items, so we should find out the best lens module without lens tilt.
    - Find the **golden** sample with smallest lens tilt.

# OTP Accuracy

- **Module amount:**
  - >20 pcs



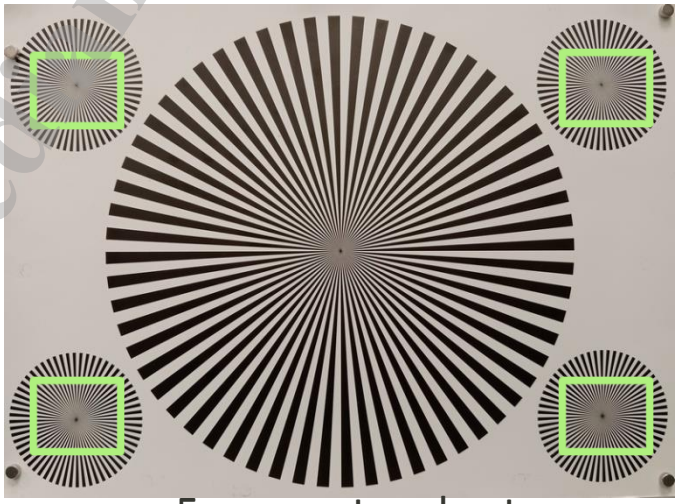
- **Test environment:**
  - Star chart.
  - >500 lux, D65.
  - Preview and warm up for >30 seconds.
  - Test Distance is the same with OTP calibration environment.

- **Collect data:**
  - Get all modules OTP infinite/macro values.
  - Get all modules fine search infinite/macro results (by EM mode fullscan).

- **Choice rule:** (find **limit** sample)
  - Find out biggest (OTP infinite value – Fine search infinite result).
  - Find out biggest (Fine search macro result - OTP macro value).

# Lens Tilt

- **Module amount:**
  - 20 pcs
- **Test environment:**
  - 5 zone star chart or ISO chart.
  - >500 lux, D65.
  - Preview and warm up for 3 minutes.
  - Test Distance for full chart capture.
- **Collect data:**
  - Get all modules fine search capture results.



5 zones star chart

- **Choice rule:** (find **golden** sample)
  - If use 5 zones star chart, find smallest sharpness differences between corner 4 zones.
  - If use ISO chart, do SFR calculate for corner 4 zones, and find smallest MTF differences.

# Golden Module Selection for AF

- Q&A
  - Q1: How to get AF OTP data?
  - A1: Check MTK log, search keyword: “OTP”

# Golden Module Selection for Lens Shading

# Golden Module Selection for Lens Shading

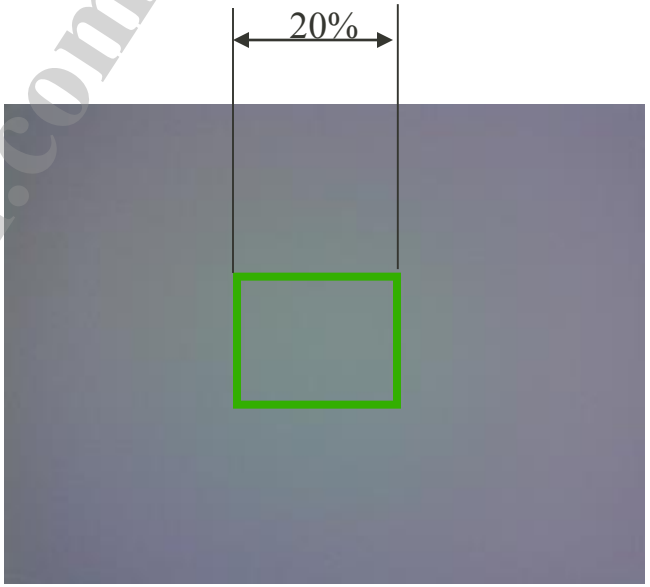
- **Lens Shading Golden needs to check 2 items:**
  - **Y decay**
  - **Color shading uniformity**

# Color Shading Uniformity

- **Module amount:**
  - >20 pcs (the more, the better)

- **Test environment:**
  - Diffuser
  - DNP
  - Sensor gain: 1X
  - Control G mean(green): 140~180 (8 bit) (after OB subtraction)
  - Disable mirror/flip

•Ask sensor FAE
•Check sensor spec




- **Collect data:**
  - Run “ShadingCalibrationSample.exe” and then “ShadingCorrectionSample.exe”
  - Check “result.txt”

Refer to 20170517_Intro_to_Shading_OTP_Tool.pdf

- **Choice rule:**
  - Golden: Green one in “Golden” tab
  - Corner: Yellow and Red ones in “Corner” tab

Refer to 20170517_LSC_Golden_Module_Selection.xls

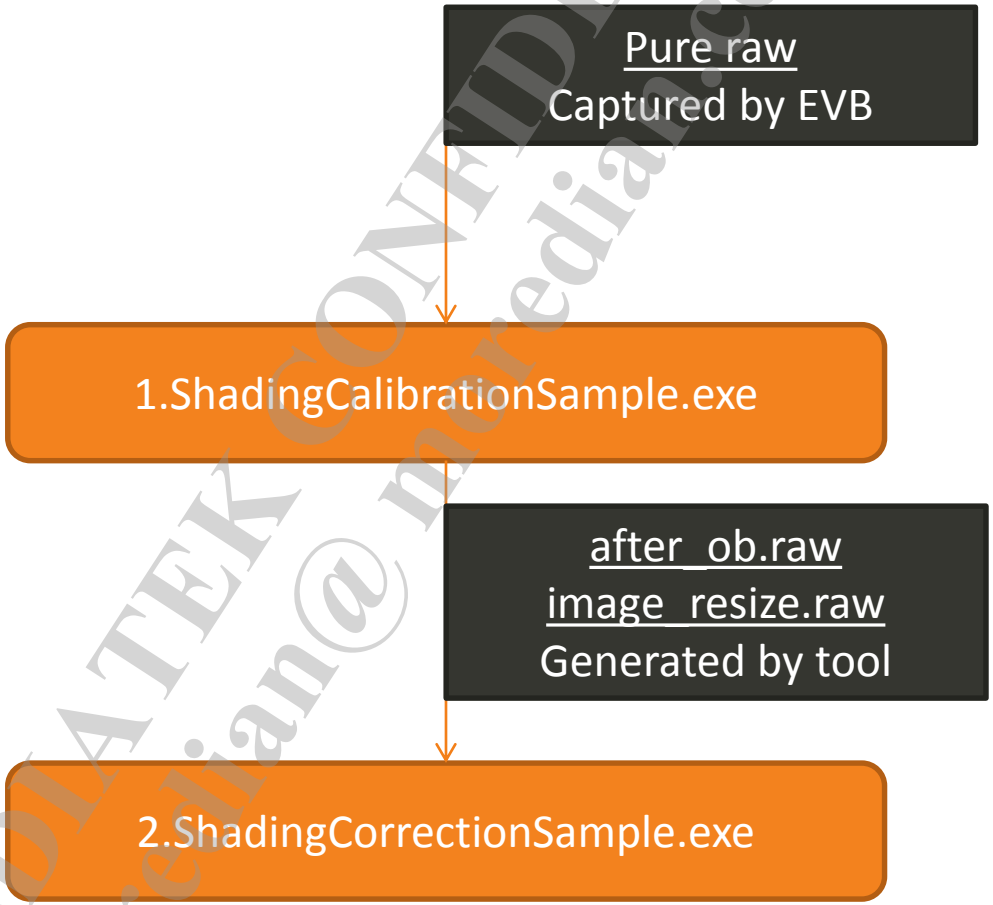
# Intro. to Shading OTP Tool

V1.1

# Version Table

| Version | Release Date | Comment |
|---|---|---|
| 1.1 | 2017/12/5 | 1. [P7] detail the description of "Compensation level"<br>2. [P15] Modify criteria part |
| 1.0 | 2016/06/14 | First release |

# Execution Flow



# 1.ShadingCalibrationSample.exe

- Description:
  - Generate OTP of shading part
- Usage:
  - 1.ShadingCalibrationSample.exe
- Input:
  - 8bit or 10bit raw
  - slim_param_capture.txt: config file
- Output:
  - after_ob.raw : for verification use
  - after_ob_correct_lo.raw: for verification use
  - image_resize.raw: for verification use
  - eeprom_slim.txt: OTP of shading part

# 1.ShadingCalibrationSample.exe slim_param_capture.txt

Filename

Image Size

Image bit-depth
Bayer order

Image Size

```
1                       //fix_shading=0,dynamic_shading=1,slim_shading=2
MONO__4208x3120_8_0.raw    //raw_image_data_in_capture_mode_lo
MONO__4208x3120_8_0.raw      //raw_image_data_in_capture_mode_md
MONO__4208x3120_8_0.raw  //raw_image_data_in_capture_mode_hi
4208x3120_8__coef.txt    //shading_coef_table_for_capture_raw_image_data
1                       //preview_mode=0,take_mode=1
4208 //src_width
3120 //src_height
8                       //src_bit_mode
0       //src_first_pixel
15                      //m_x_grid_num
15                      //n_y_grid_num
0                       //Gr/Gb_apply_the_same_table
0                       //src_offset_x0
0                       //src_offset_y0
4208 //src_offset_x1
3120 //src_offset_y1
```

# 1.ShadingCalibrationSample.exe slim_param_capture.txt

Compensation level

OB Value

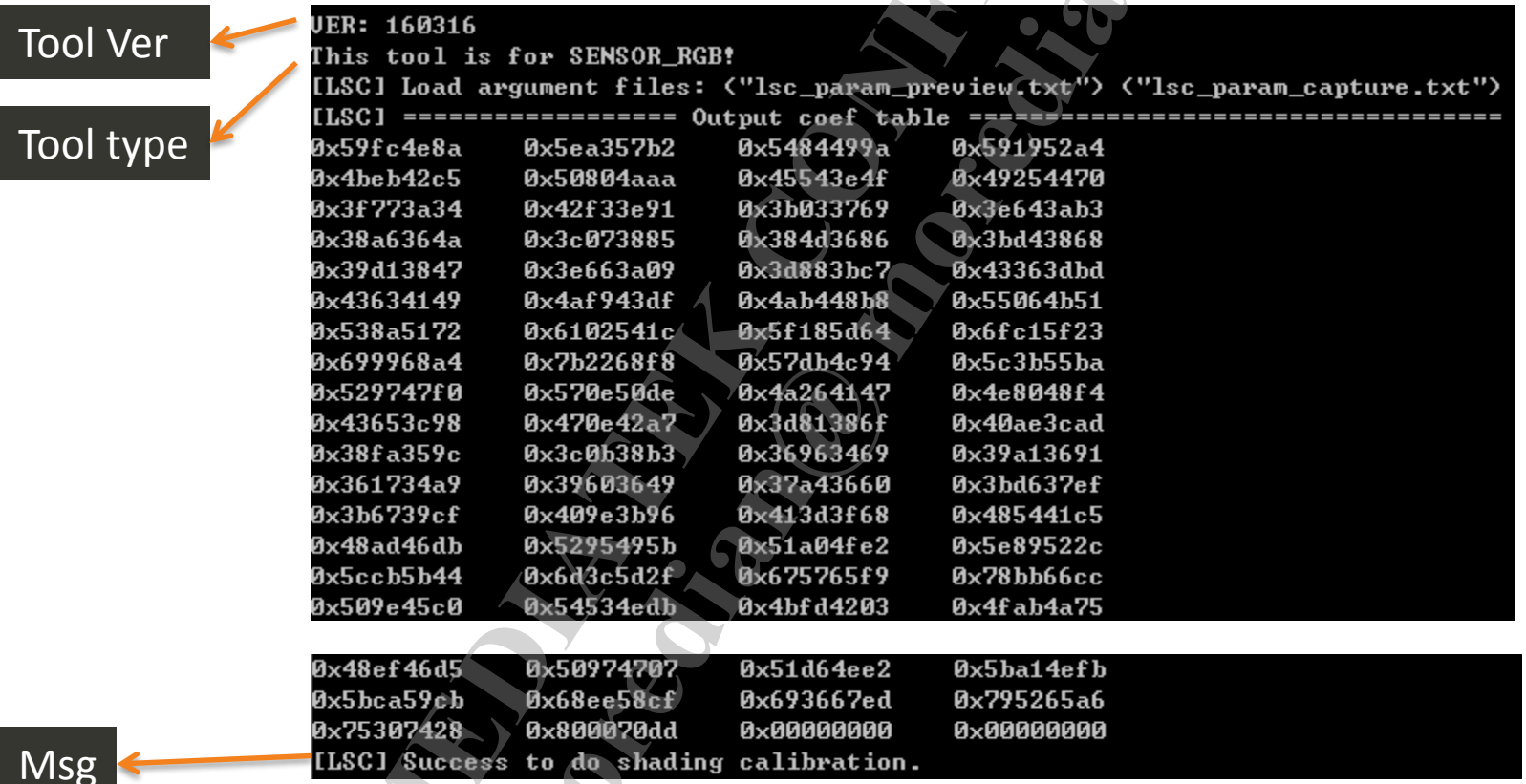
```
33                    //block_avg_width
0                     //correction_level
1          //gModifyGetMaxVal
1                     //gModifySetLscCur
0                     //Pattern_distribution_center_X_Pixel_offset
0                     //Pattern_distribution_center_Y_Pixel_offset
40 //Max_Pixel_Gain_divide_to_10_for_real_gain
-1507556//Pattern_distribution_coef_a_ax5+bx4+cx3+dx2+ex+f
2574222//Pattern_distribution_coef_b_ax5+bx4+cx3+dx2+ex+f
-1463111//Pattern_distribution_coef_c_ax5+bx4+cx3+dx2+ex+f
196444//Pattern_distribution_coef_d_ax5+bx4+cx3+dx2+ex+f
0                     //Pattern_distribution_coef_e_ax5+bx4+cx3+dx2+ex+f
1000000 //Pattern_distribution_coef_f_ax5+bx4+cx3+dx2+ex+f
0                     //OB Value
```

# 1.ShadingCalibrationSample.exe slim_param_capture.txt

- Filename:
  - input raw file name
- Image Size:
  - Input raw width and height
- Image bit-depth
  - Input raw bit-depth: 8 or 10 bit
- Bayer order
  - Input raw bayer order:
    - 0: B, 1: Gb, 2: Gr, 3: R
- OB Value
  - Black level: value range is along with image bit-depth.
- Compensation level
  - 0 (full compensation)~ 20 (no compensation)
  - How to know the step size:
    - For example:
      - If set to 0 (full compensation), the measured Max_Y_Decay is 100%.
      - If set to 20 (no shading compensation), the measured Max_Y_Decay keeps unchanged. EX.30%.
      - The step size is (100% – 30%)/20 = 3.5%
      - the measured Max_Y_Decay's tolerance is ±1 step size.
        - » This means if you set the level to 10, the measured Max_Y_Decay is 65% ± 3.5%

# 1.ShadingCalibrationSample.exe

- Screenshot



# 1.ShadingCalibrationSample.exe Error Code

```
typedef enum{
    CALIBRATION_SUCCESS,            // Success to do shading calibration
    CALIBRATION_FAIL,               // Fail to do shading calibration
    STEP_OK,                        // STEP OK - internal use
    INVALID_RAW_DATA_NULL,          // Fail to load image raw data
    INCOMPLETE_INITIALIZATION,      // Fail to initilize paramters
    EXCEED_SHADING_TABLE_SIZE,      // Fial because of exceeding shading table size
    FAIL_TO_FILL_SHADING_TABLE,     // Fail to fill shading table
    OVERFLOW_HARDWARE_BITS,         // Overflow hardward bits
    WRITE_COEF_FAIL,                // Fail to wrtie coef file
}SHADING_CALIBRATION_RESULT;
```

# 2.ShadingCorrectionSample.exe

- Description:
  - Verification on calibrated result
- Usage:
  - 2.ShadingCorrectionSample.exe
- Input:
  - after_ob.raw
  - after_ob_correct_lo.raw
  - image_resize.raw
  - lsv_param_capture.txt: config file
- Output:
  - result.txt: verification result

# 2.ShadingCorrectionSample.exe lsv_param_capture.txt

```
after_ob.raw              //raw_image_data_in_capture_mode_LO
after_ob_correct_lo.raw   //raw_image_after_LSC_LO
after_ob.raw              //raw_image_data_in_capture_mode_MD
after_ob_correct_lo.raw   //raw_image_after_LSC_MD
after_ob.raw              //raw_image_data_in_capture_mode_HI
after_ob_correct_lo.raw   //raw_image_after_LSC_HI
1                         //preview_mode=0,take_mode=1
2104 //src_width
1560                      //src_height
8                         //src_bit_mode
0                         //src_first_pixel
```

Image Size
Half of input raw

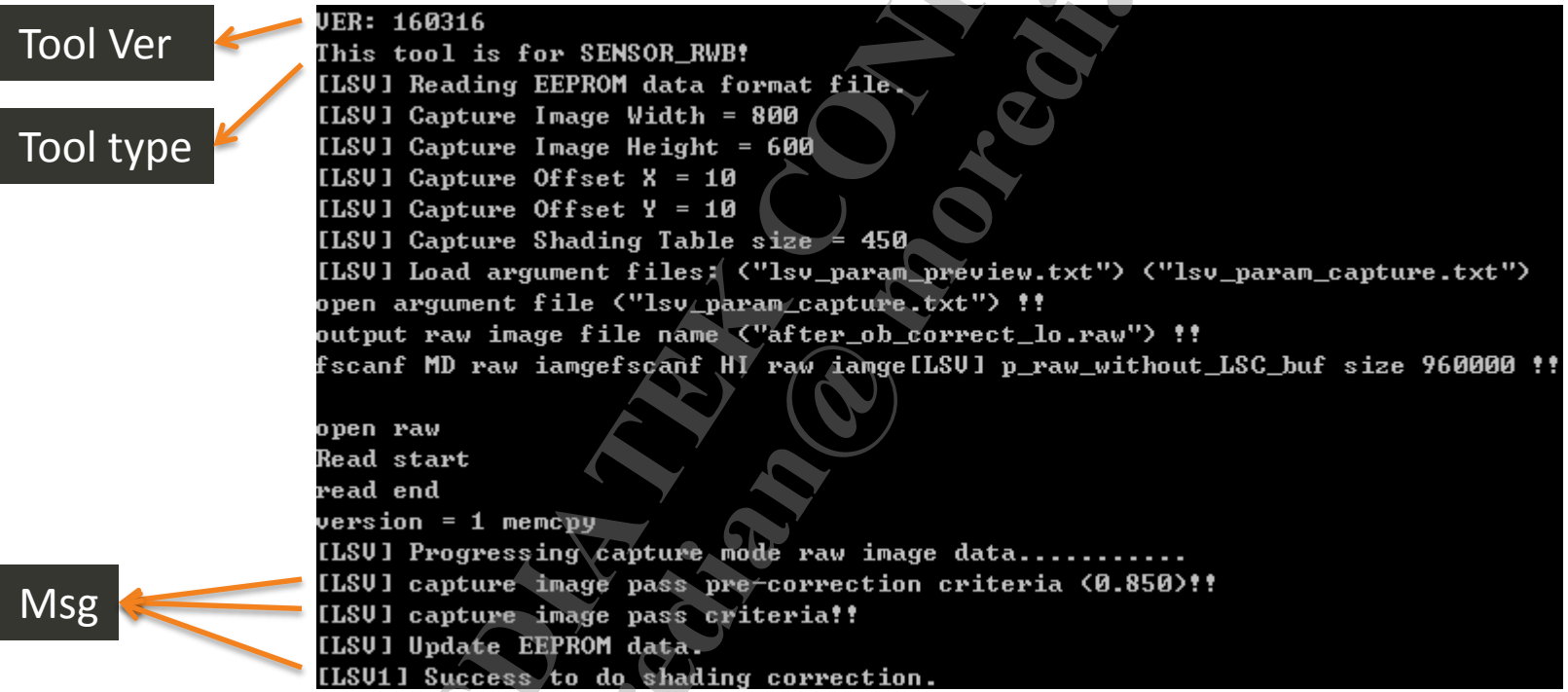
Image bit-depth
Bayer order

# 2.ShadingCorrectionSample.exe lsv_param_capture.txt

- Image Size:
  - Input raw width/2 and height/2
- Image bit-depth
  - Input raw bit-depth: 8 or 10 bit
- Bayer order
  - Input raw bayer order:
    - 0: B, 1: Gb, 2: Gr, 3: R

# 2.ShadingCorrectionSample.exe

- Screenshot



# 2.ShadingCorrectionSample.exe Error Code

```
typedef enum{
    CORRECTION_SUCCESS,             // Success to do shading correction
    CORRECTION_FAIL,                // Fail to do shading correction
    INIT_PARA_FAIL,                 // Fail to initlize paramter for shading correction
    FREE_MEM_FAIL,                  // Fail to free internal allocated memory
    MEM_INIT_FAIL,                  // Fail to allocate internal usage memeory
    IMAGE_LOADING_FAIL,             // Fail to load image data fail
    BUFFER_FOR_LSC_IMAGE_NULL,      // Fail to copy result shading correctio image because there is no buffer for image with shading correction
    GAIN_TABLE_FAIL,                // Fail in gain table check
    LUM_TEST_FAIL,                  // Fail in lum test
    PRECOR_TEST_FAIL,               // Fail in pre correction test
    FALLOFF_TEST_FAIL,              // Fail in falloff test
    COLOR_TEST_FAIL,                // Fail in color test
}SHADING_CORRECT_RESULT;
```

# Criteria

| Before Calibration | MONO Sensor | Bayer Sensor | RWB Sensor | Error Code |
|---|---|---|---|---|
| G mean of □ : (8bit)<br>(After OB subtraction) | 140 ~ 180 | 140 ~ 180 | 140 ~ 180 | LUM_TEST_FAIL |
| min (R/G) / max (R/G) | > 95% | > 70% | > 70% | PRECOR_TEST_FAIL |
| min (B/G) / max (B/G) | > 95% | > 70% | > 70% | PRECOR_TEST_FAIL |
| max(G)/min(G) | < 4 | < 4 | < 4 | OVERFLOW_HARDWARE_BITS |

| After Calibration | MONO Sensor | Bayer Sensor | RWB Sensor | Error Code |
|---|---|---|---|---|
| G mean of □ : (8bit)<br>(After OB subtraction) | 140 ~ 180 | 140 ~ 180 | 140 ~ 180 | LUM_TEST_FAIL |
| Min (G decay) | > 70% | > 70% | > 70% | FALLOFF_TEST_FAIL |
| Max (Color diff) | < 5% | < 5% | < ( 5% / color_gain ) | COLOR_TEST_FAIL |

# Golden Module Selection for ISP Generic Estimation

# Golden Module Selection

- Platform Sensor Setting Check
- Select Golden Sample for IQ Tuning
  - RAW Sharpness – MTF50
  - RAW Noise – SNR @ G channel

# Platform Sensor Setting Check

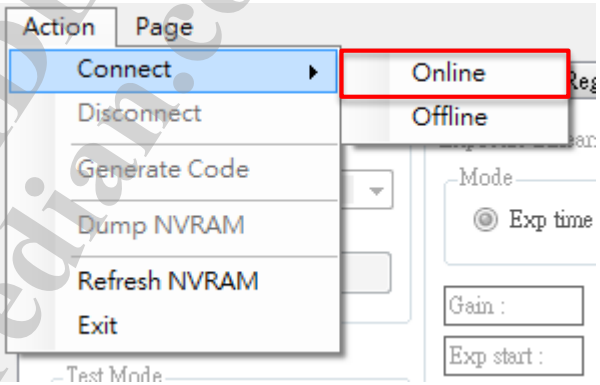
- ✓ Ensure no additional sensor modules are activated unexpectedly

# Platform Sensor Setting Check

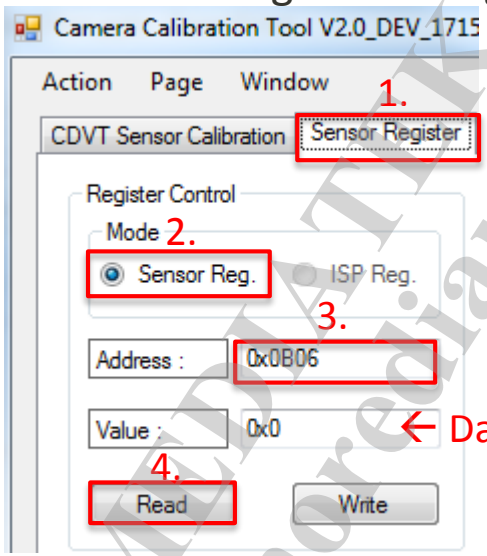
- Check register info from datasheet

| Example: IMX338 | Register address | Configuration | |
|---|---|---|---|
| | | Disable | Enable |
| LSC@Normal | R0x0B00[0] | 0 | 1 |
| LSC@HDR | R0x3000[0] | 0 | 1 |
| Static DPC | R0x0B05[0] | 0 | 1 |
| Dynamic DPC | R0x0B06[0] | 0 | 1 |
| HDR MODE | R0x0220[0] | 0 | 1 |
| CNR@Normal | R0x30A2[1] | 0 | 1 |
| CNR@HDR | R0x3004[1] | 0 | 1 |
| ARNR@Normal | R0x30A2[0] | 0 | 1 |
| ARNR@HDR | R0x3004[0] | 0 | 1 |

- Method: Execute CCT connected to Phone




- Operation of reading sensor register value on the fly




1. Switch to Tab of Sensor Register
2. Select Sensor Register
3. Key in Register Address
4. Push Read Button and get reading out on Value text box

# RAW Sharpness

**Pure RAW is captured with normal AE**

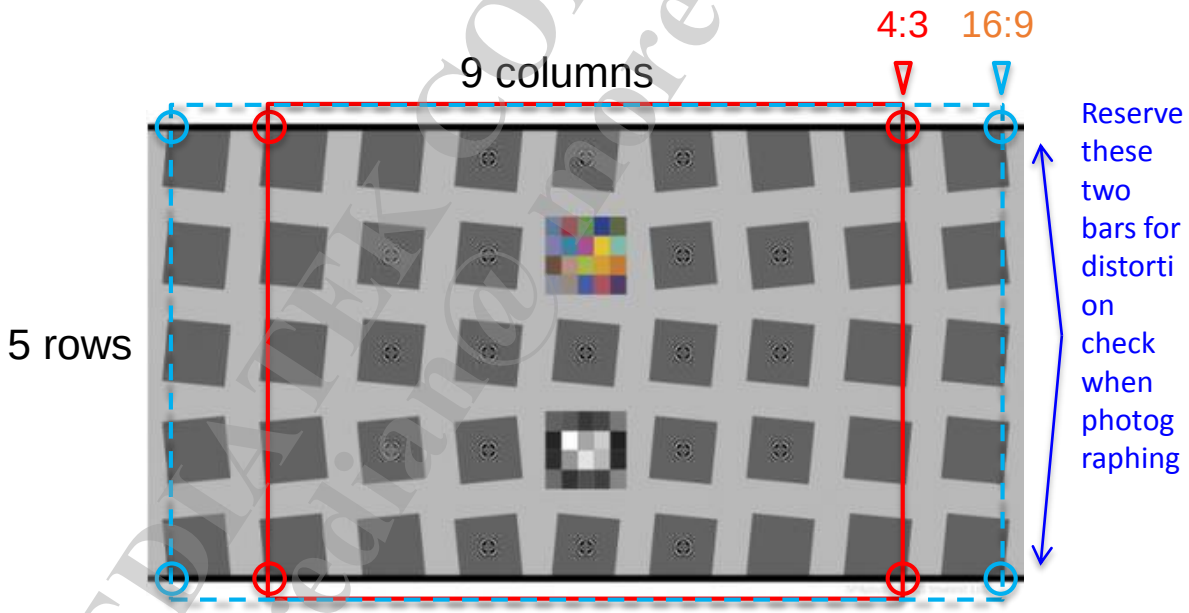
- ✓ Get golden unit with higher MTF value among samples

# RAW Sharpness – EM Setting

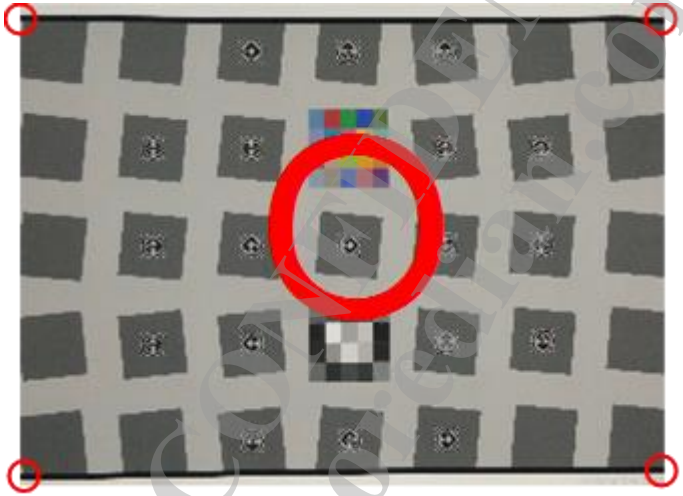
- **EM Capture RAW setting**
  - Camera Sensor : Main
  - Capture mode : Normal Capture
  - Capture size : Capture size
  - Capture ratio : 4:3
  - Capture type : Pure Raw
  - Capture number : 1
  - Shutter speed (ms) : 0
  - Sensor gain (1.0=1024) : 0
  - Flicker : 50Hz (China), 60Hz (Taiwan)
  - Strobe Mode : OFF
  - HDR Debug : OFF
  - Shutter Delay : 5 s
  - Shading Table : TSF
  - Multi Pass NR : Auto
  - MFLL : OFF
  - ISO interpolation OFF
  - Flash Calibration : OFF
  - Scene mode : Auto
  - AWB Verification : All OFF
  - Shading Verification : All ON
  - AF : Full Scan
  - Custom Parameter :
  - Capture : Start Preview

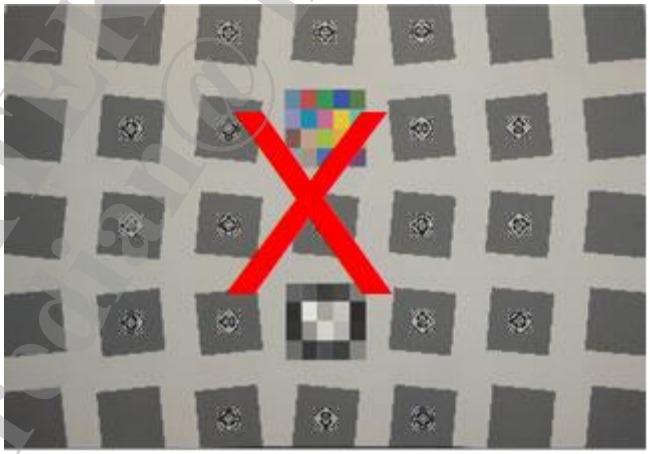
# RAW Sharpness – FOV (1/2)

- With tripod
- 1000 lux @ Day Light
- Capture distance : 4:3 full screen



# RAW Sharpness – FOV (2/2)





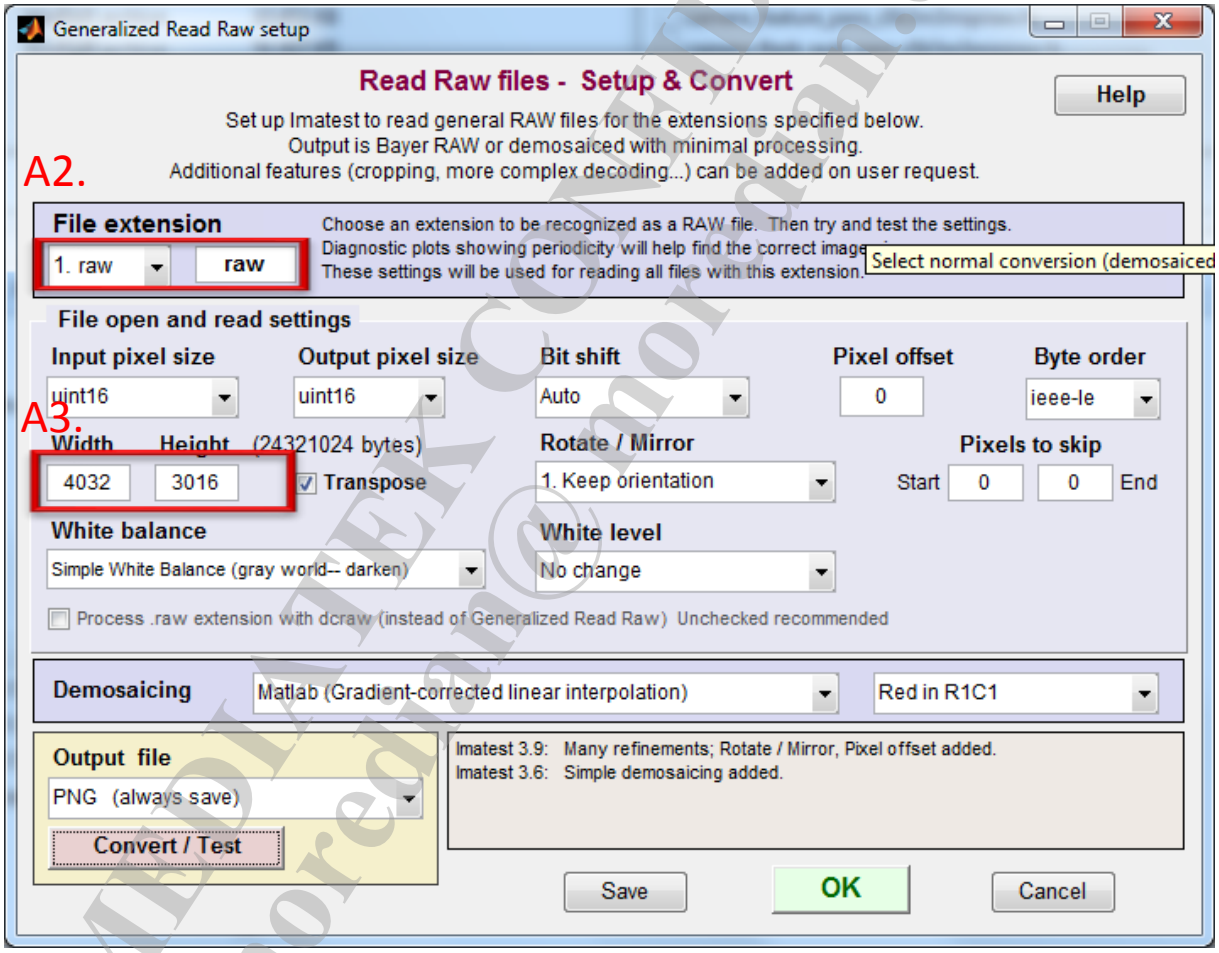
# RAW Sharpness – Read Raw (1/8)

- A1. Run Imatest “Read Raw “ to…
  - Demosaic pure RAW
  - Frame base AWB
  - save as a PNG for MTF measurement


A1.

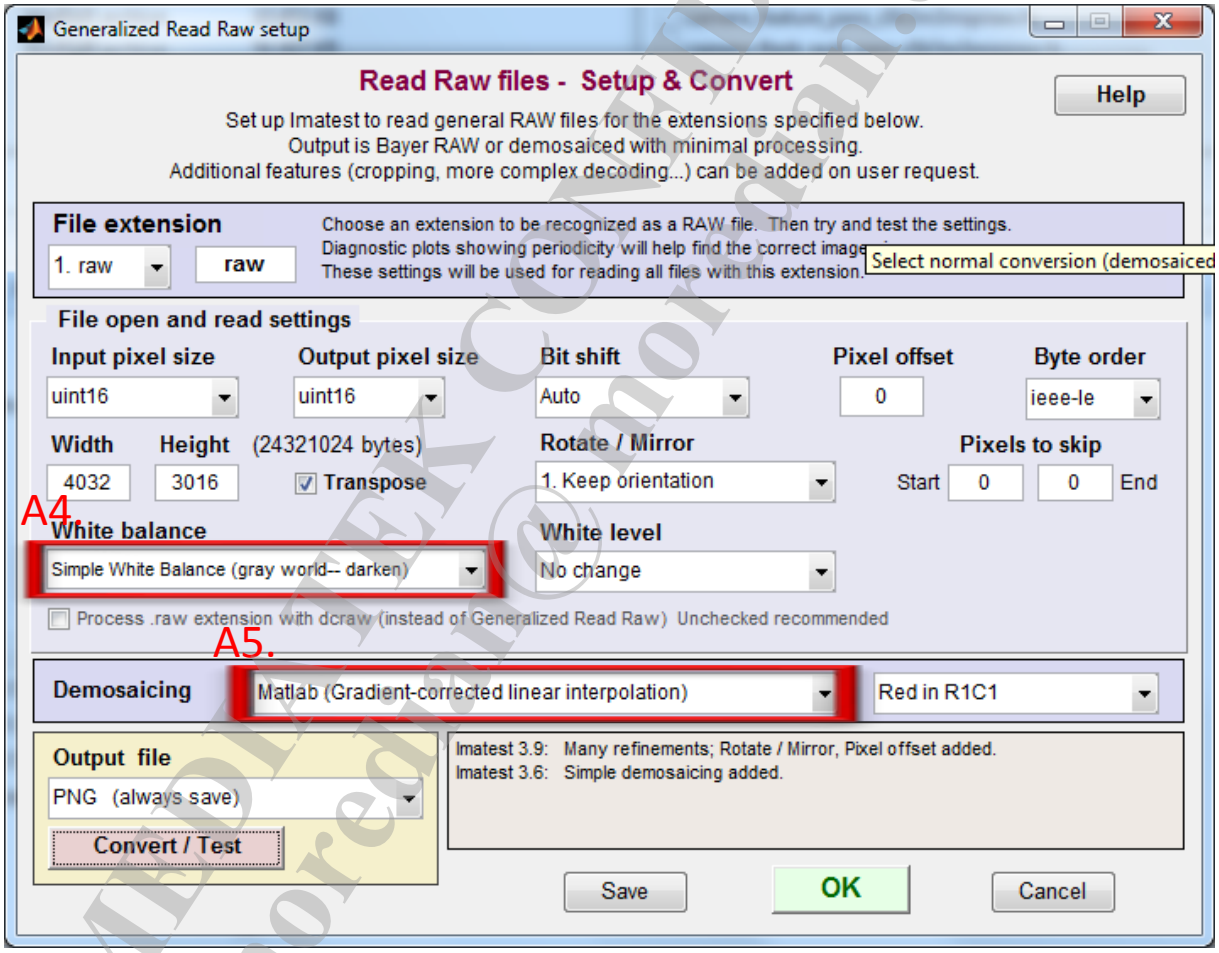
# RAW Sharpness – Read Raw (2/8)

- A2. Choose an extension and place “raw” as been recognized
- A3. Input raw size



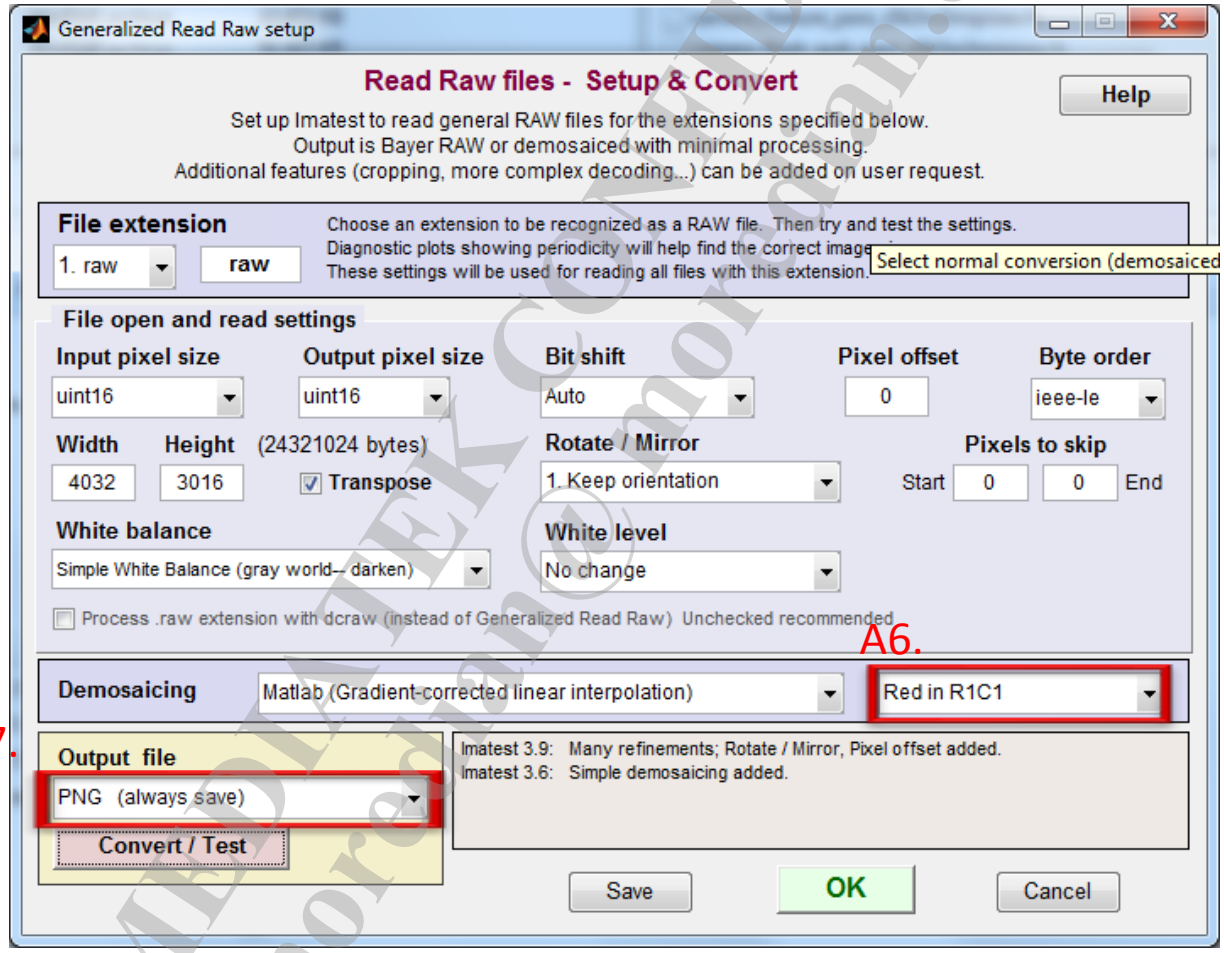
# RAW Sharpness – Read Raw (3/8)

- A4. Select “Simple White Balance (gray world– darken)”
- A5. Select “Matlab (Gradiend-corrected linear interpolation)”



# RAW Sharpness – Read Raw (4/8)

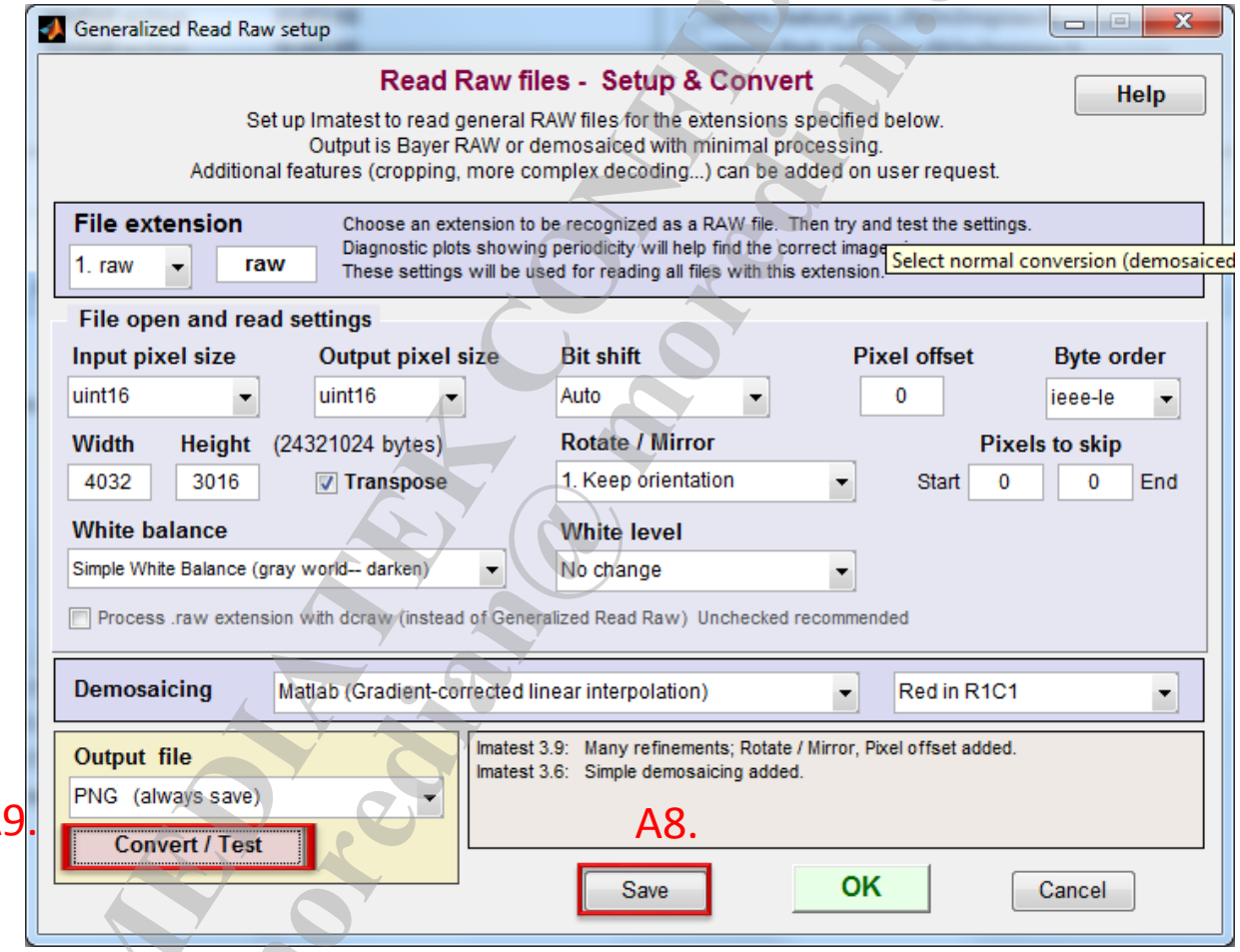
- A6. Select Bayer Order of RAW format
- A7. Select “PNG (always save)” for file type of convert output




Depends on bayer order
0: (BGGR) Red in R2C2
1: (GBRG) Red in R2C1
2: (GRBG) Red in R1C2
3: (RGGB) Red in R1C1

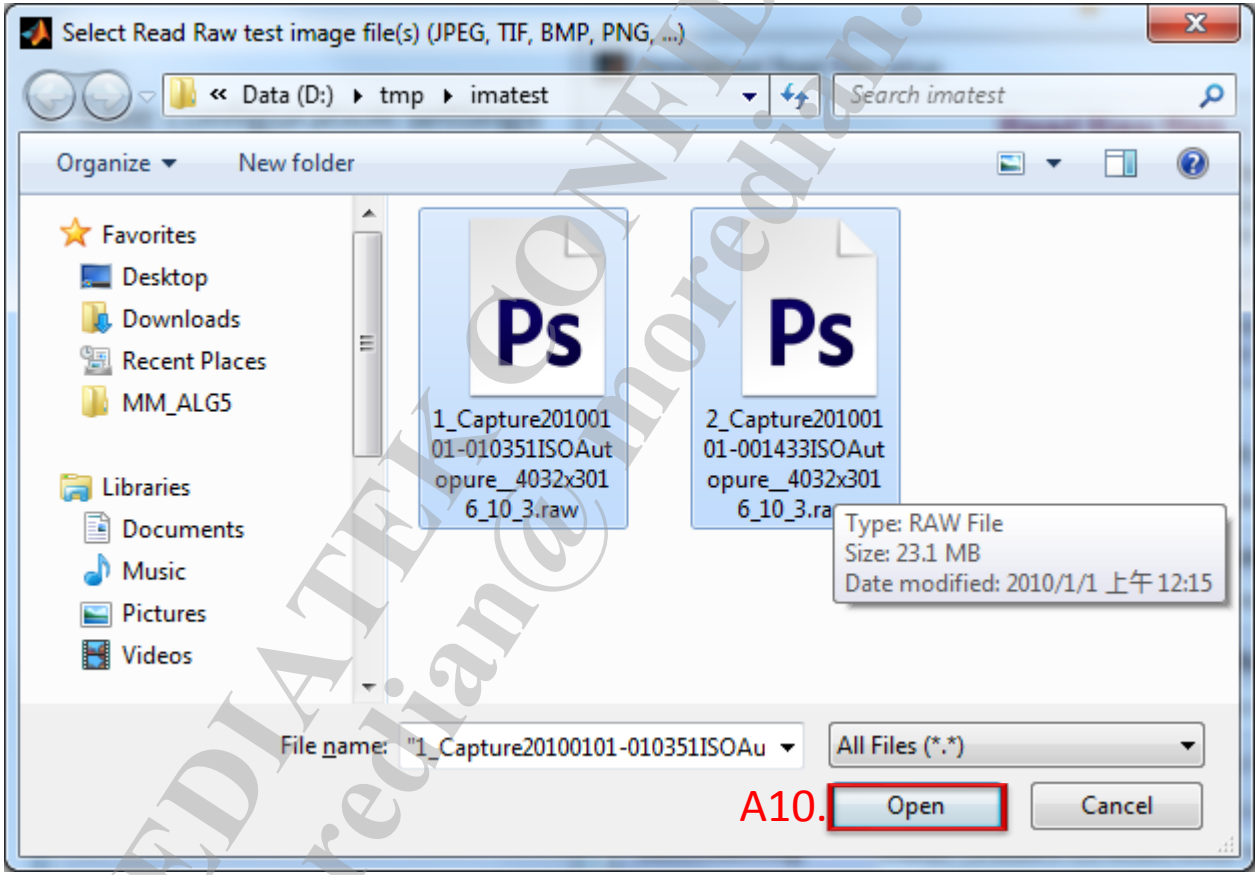
# RAW Sharpness – Read Raw (5/8)

- A8. Save configuration settings
- A9. Start to convert RAW



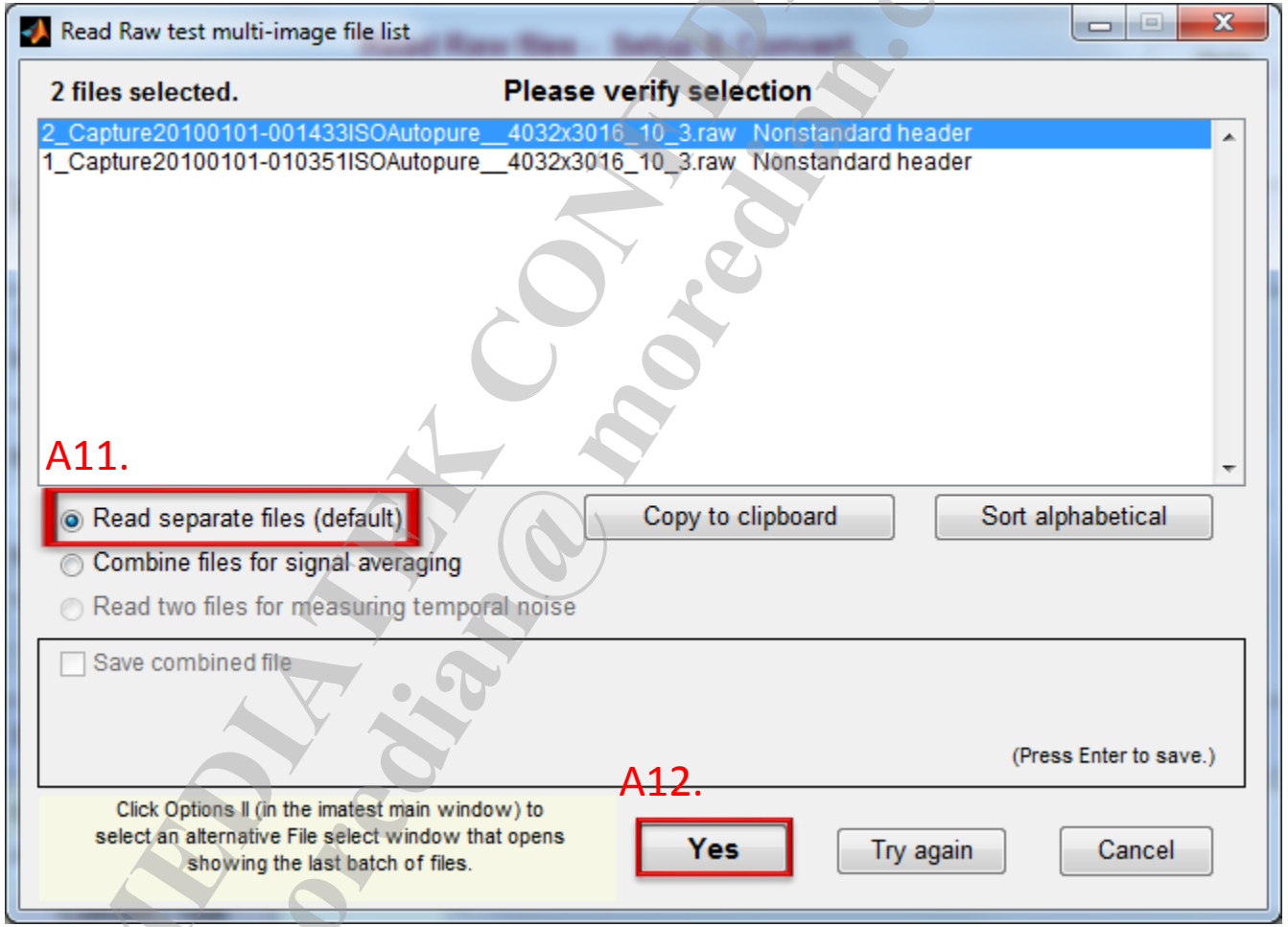
# RAW Sharpness – Read Raw (6/8)

- A10. Select/Multi-Select pure RAW file and click “Open”



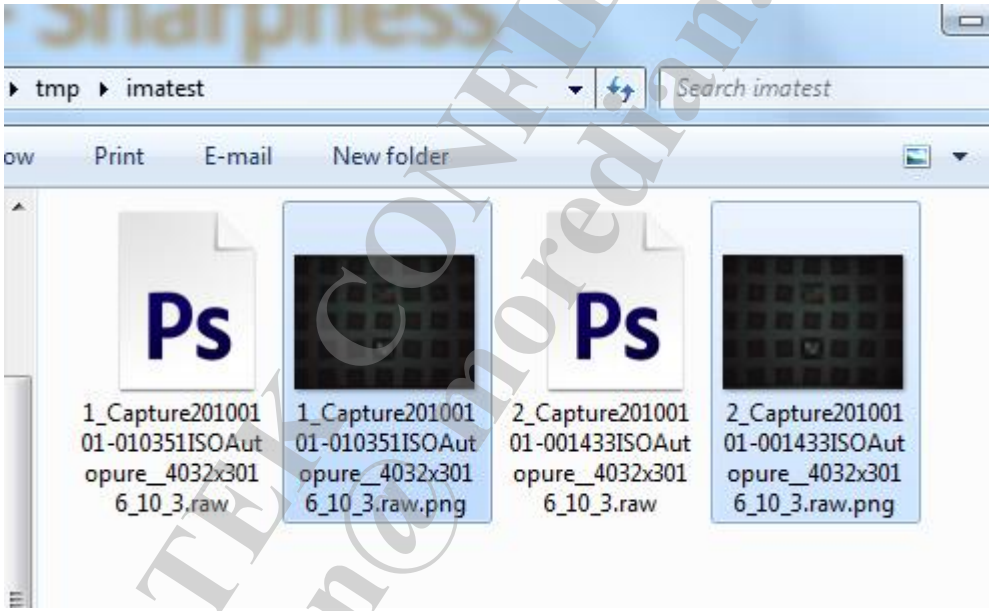
# RAW Sharpness – Read Raw (7/8)

- A11. Check “Read separated files (default)” if you apply for multi-select
- A12. Click “Yes” for saving file



# RAW Sharpness – Read Raw (8/8)

- Output file is stored in the same folder as RAW file



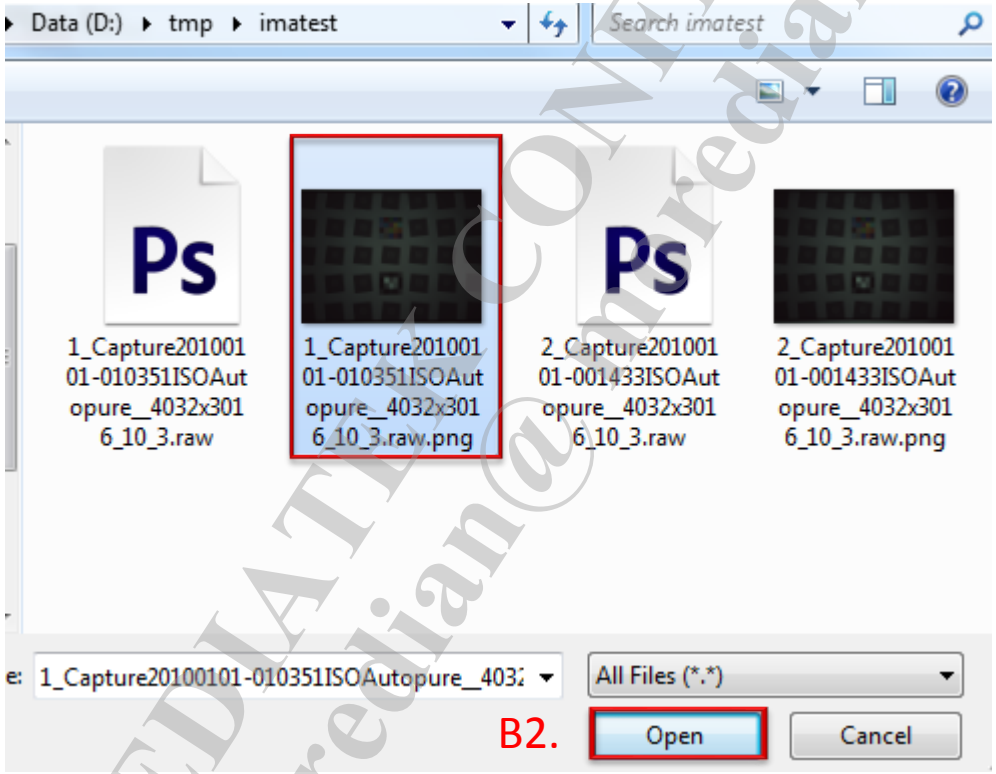
# RAW Sharpness – Measure MTF (1/9)

- B1. Use Imatest SFRPlus to…
  - Setup SFRPlus configuration
  - Measure MTF50 for files in a time

B1.

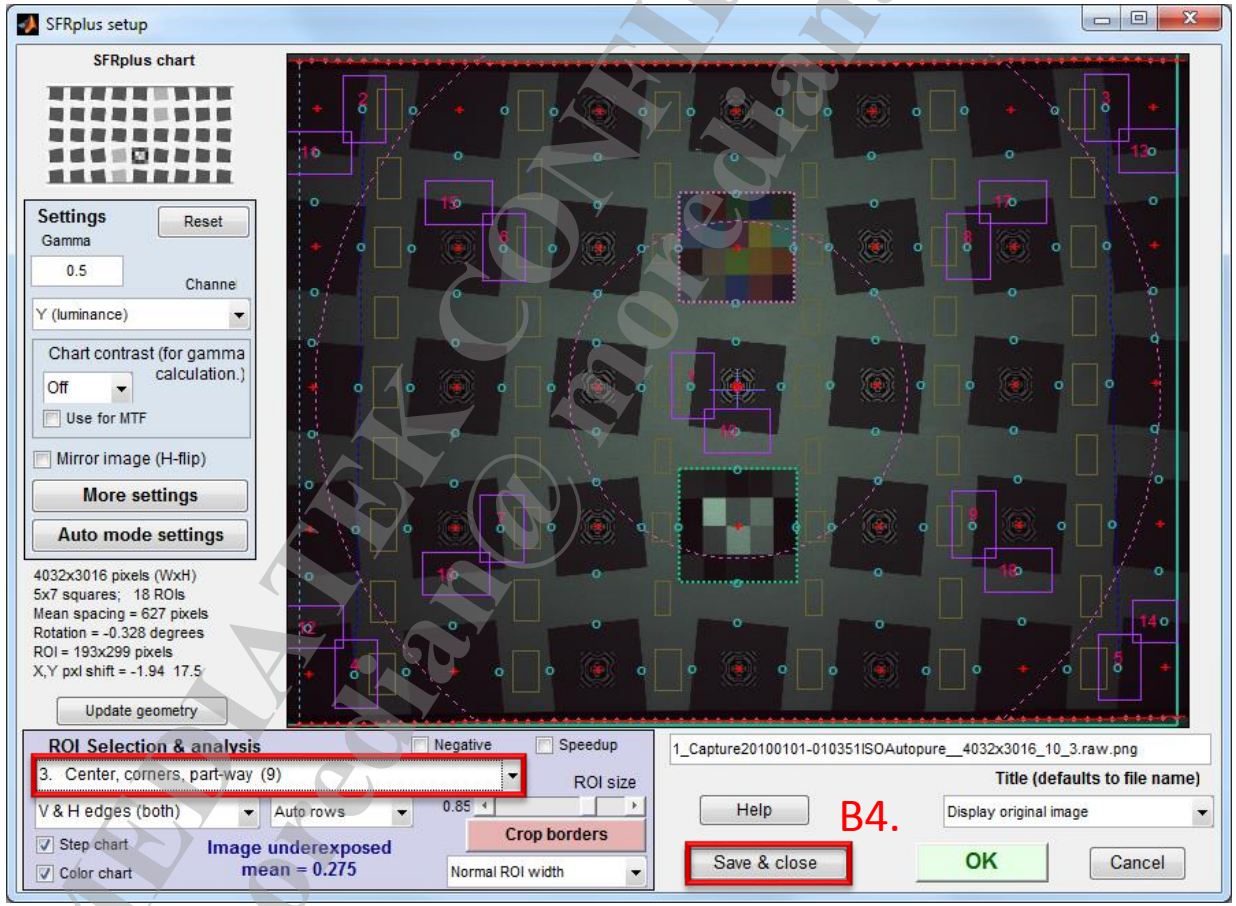
# RAW Sharpness – Measure MTF (2/9)

- B2. Select the PNG file which is converted via Imatest Read Raw, then click "Open"



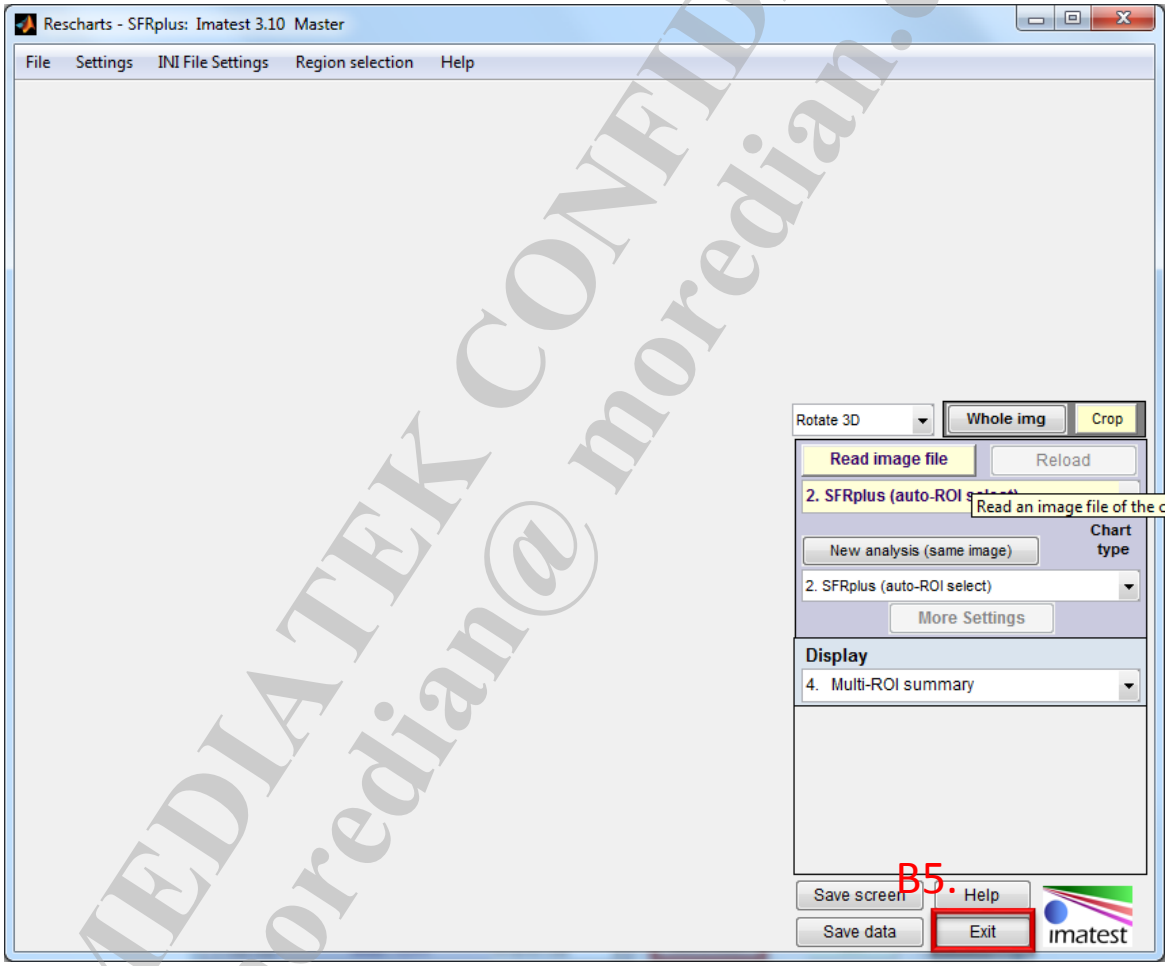
# RAW Sharpness – Measure MTF (3/9)

- B3. Select the “3. Center, corners, part-way (9), and check purple rectangles are placed correctly
- B4. Click “Save & close”



# RAW Sharpness – Measure MTF (4/9)

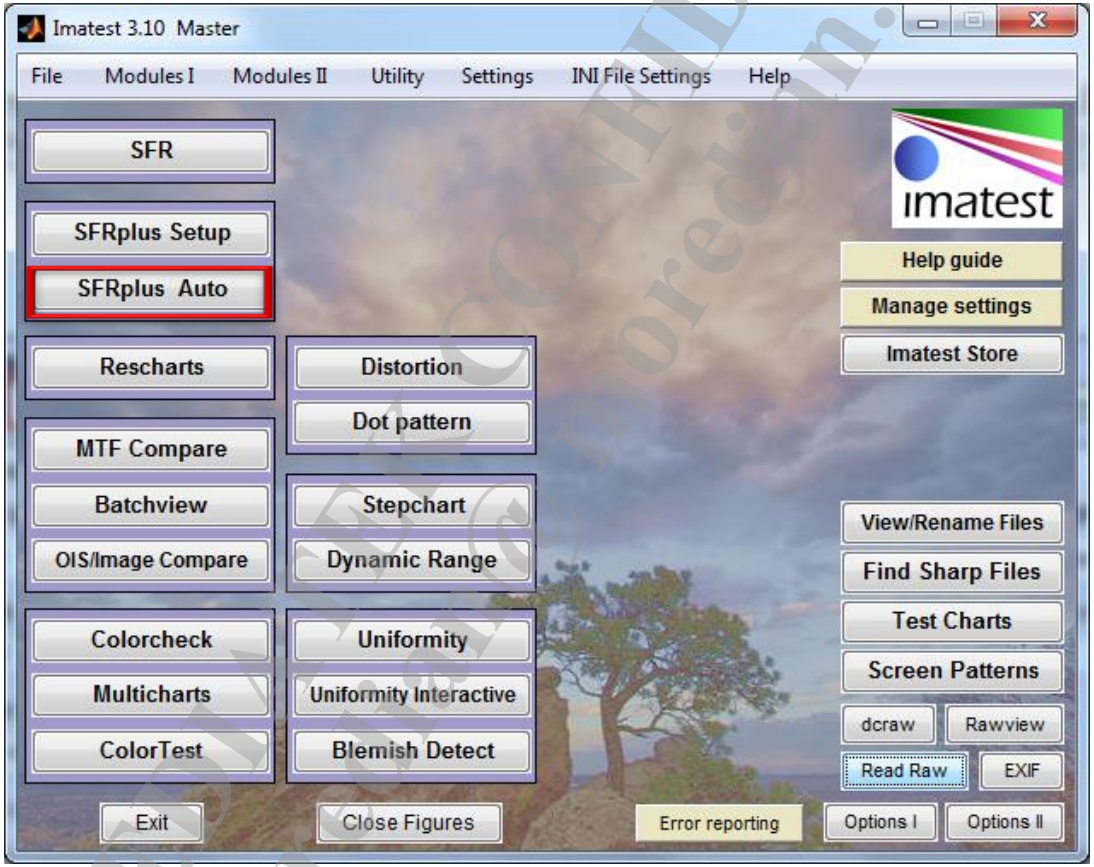
- B5. Click “Exit”, latter on we will use “SFRPlus Auto” for multi-files measurement in a time



# RAW Sharpness – Measure MTF (5/9)

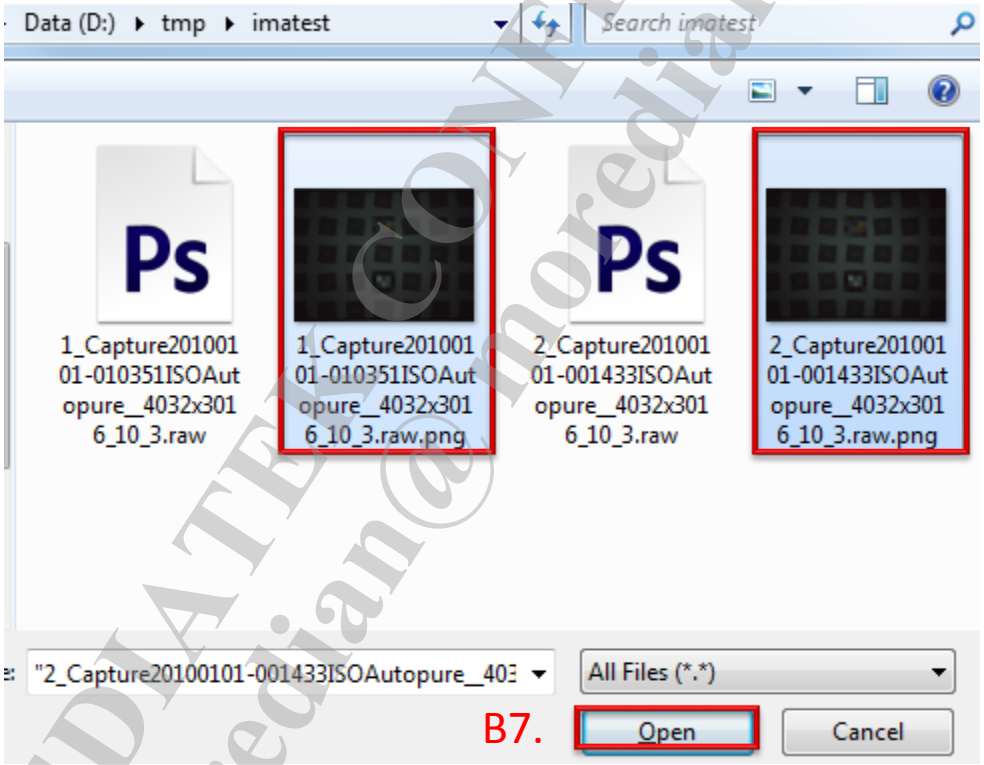
- B6. Push “SFRPlus Auto”

B6.



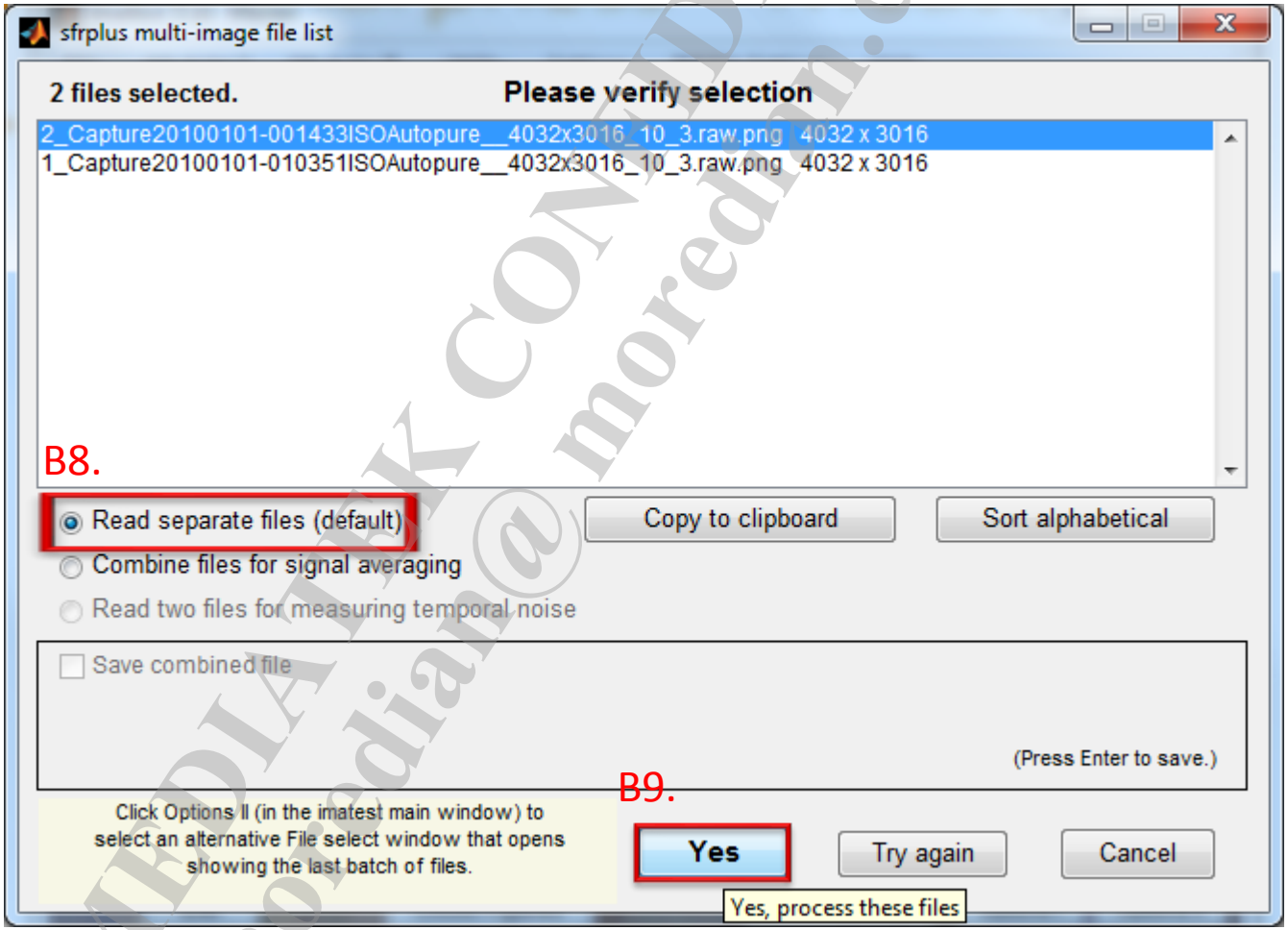
# RAW Sharpness – Measure MTF (6/9)

- B7. Select/Multi-select the PNG file which is converted via Imatest Read Raw, then click “Open”



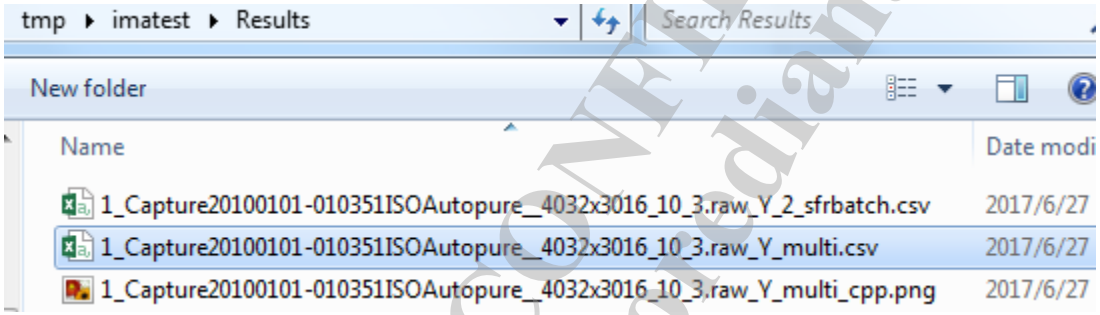
# RAW Sharpness – Measure MTF (7/9)

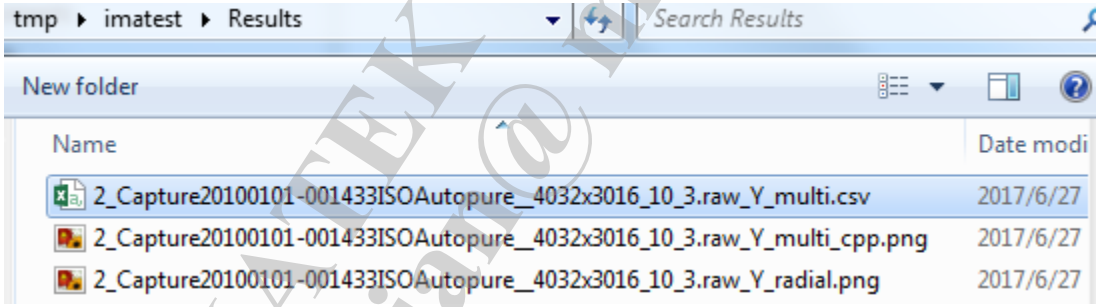
- B8. Check “Read separated files (default)” if you apply for multi-select
- B9. Click “Yes” for saving file



# RAW Sharpness – Measure MTF (8/9)

- B10. When executing SFRPlus Auto is done, open the Results\ xxx.raw_Y_multi.csv under the folder of RAW file

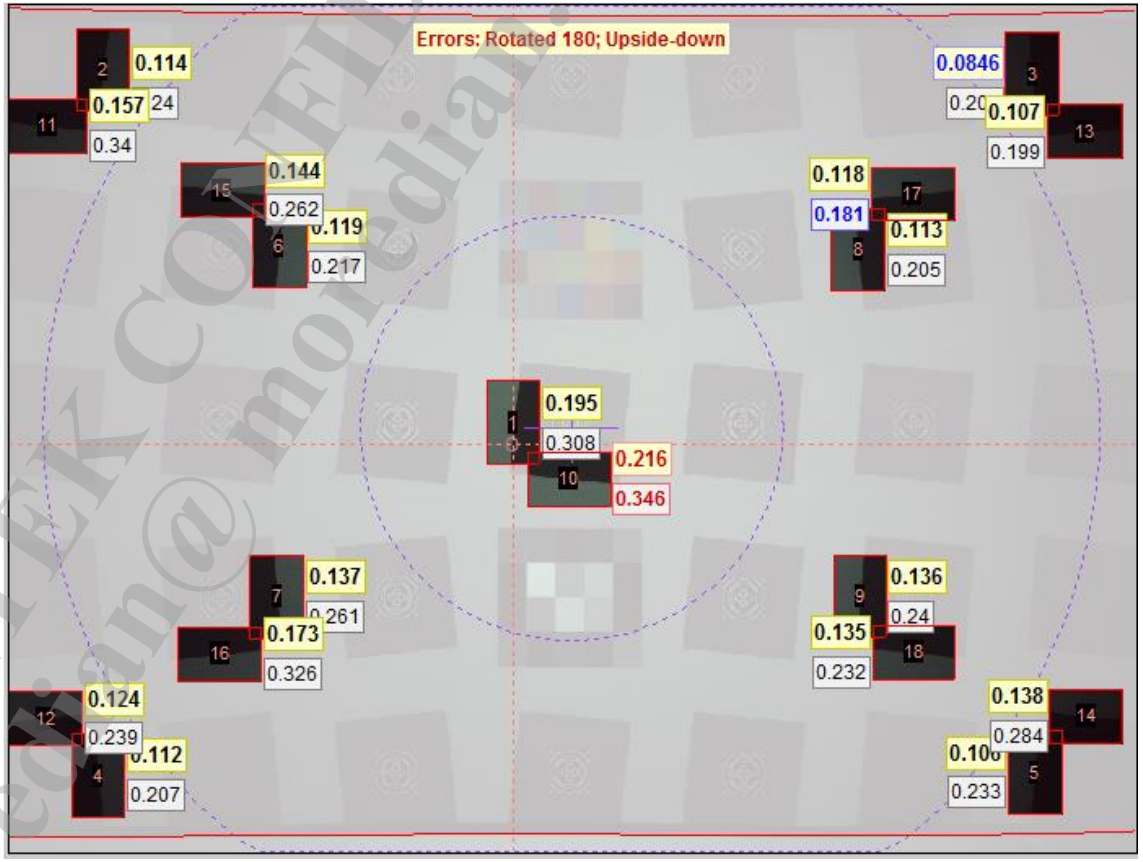


# RAW Sharpness – Measure MTF (9/9)

- The cell #B49~B57 are the MTF50 values from patches

| | A | B |
|---|---|---|
| 47 | Primary results | |
| 48 | N | MTF50 (Cy/Pxl) |
| 49 | 1 | 0.1951 |
| 50 | 2 | 0.1138 |
| 51 | 3 | 0.0846 |
| 52 | 4 | 0.1122 |
| 53 | 5 | 0.1062 |
| 54 | 6 | 0.1189 |
| 55 | 7 | 0.1374 |
| 56 | 8 | 0.1131 |
| 57 | 9 | 0.1363 |
| 58 | 10 | 0.216 |
| 59 | 11 | 0.1573 |
| 60 | 12 | 0.1241 |
| 61 | 13 | 0.1069 |
| 62 | 14 | 0.1375 |
| 63 | 15 | 0.1441 |
| 64 | 16 | 0.1733 |
| 65 | 17 | 0.118 |
| 66 | 18 | 0.1352 |



# RAW Sharpness - Example

- Example of the MTF selection (4032x3016)

| Module 編號 | MTF 50 [Cy/Pxl] | | | | | Ranking |
|---|---|---|---|---|---|---|
| | MTF 中心 | MTF 左上 | MTF 右上 | MTF 左下 | MTF 右下 | |
| 1 | 0.1853 | 0.1087 | 0.1074 | 0.0982 | 0.1135 | 8 |
| 2 | 0.1962 | 0.1112 | 0.0801 | 0.1104 | 0.1027 | 16 |
| 3 | 0.2389 | 0.1057 | 0.1155 | 0.1145 | 0.1267 | 3 |
| 4 | 0.1836 | 0.1116 | 0.1218 | 0.1249 | 0.1333 | 8 |
| 5 | 0.2591 | 0.1061 | 0.1048 | 0.1181 | 0.114 | 1 |
| 6 | 0.255 | 0.1061 | 0.1034 | 0.1049 | 0.1049 | 1 |
| 7 | 0.2058 | 0.1184 | 0.1049 | 0.1262 | 0.1009 | 5 |
| 8 | 0.185 | 0.1034 | 0.1131 | 0.1076 | 0.107 | 8 |
| 9 | 0.2291 | 0.1212 | 0.0997 | 0.1179 | 0.1163 | 5 |
| 10 | 0.1838 | 0.1105 | 0.0915 | 0.12 | 0.1028 | 20 |
| 11 | 0.1934 | 0.1136 | 0.0811 | 0.1149 | 0.094 | 16 |
| 12 | 0.1992 | 0.1286 | 0.1439 | 0.133 | 0.1357 | 8 |
| 13 | 0.2003 | 0.0992 | 0.1185 | 0.1068 | 0.1318 | 8 |
| 14 | 0.2206 | 0.1058 | 0.0987 | 0.1099 | 0.1092 | 3 |
| 15 | 0.2074 | 0.1142 | 0.1136 | 0.1165 | 0.1113 | 5 |
| 16 | 0.2283 | 0.1022 | 0.0987 | 0.0722 | 0.1019 | 8 |
| 17 | 0.208 | 0.0889 | 0.0928 | 0.1036 | 0.0772 | 8 |
| 18 | 0.2071 | 0.0991 | 0.0855 | 0.1119 | 0.0993 | 8 |
| 19 | 0.2048 | 0.0942 | 0.0696 | 0.1117 | 0.0983 | 16 |
| 20 | 0.1701 | 0.1134 | 0.0918 | 0.1258 | 0.0939 | 16 |

- Pass Criterial:
  - ✓ Higher MTF value of center
    (Center 0.25Cy/Pxl: 3016/2/2 = 754 Lp/pH)
  - ✓ Consistent MTF corners
    (Expected 40% of center MTF)

- Result:
  - ❖ Rank all units
  - ❖ Propose acceptable performance
    (Green cell in Ranking column)

# RAW Noise

**Pure RAW is captured with:**
**Shutter speed 1/30 sec**
**ISO800**
**LSB D5000 LV5 (common case)**

- ✓ The SNR of Bayer Green channel reaches 22 dB

# RAW Noise - ROI

- Check the pure RAW noise in Signal to Noise Ratio **on G channels**

Data form (histogram(RAW))

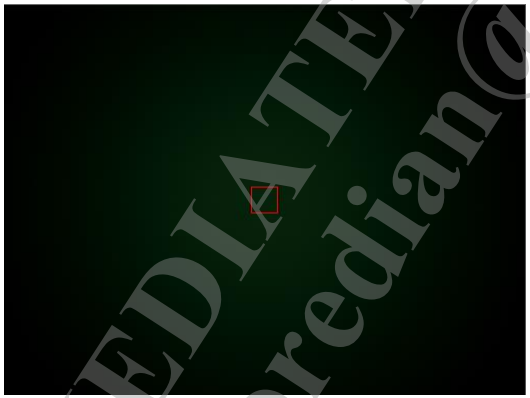
File

$SNR_{R/Gr/Gb/B} = 20 \log(Mean/STD)$

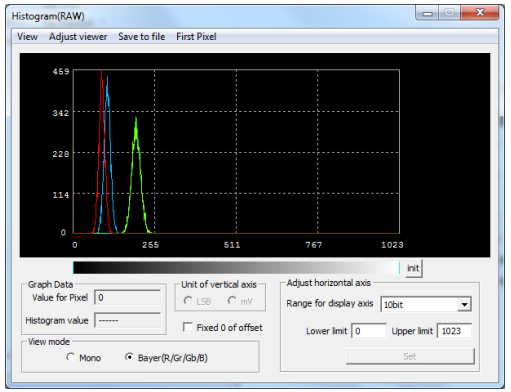
| Area Name | X1 | Y1 | X2 | Y2 | Maximum ... | Minimum v... | Average | Standard deviation | PeakToPeak |
|---|---|---|---|---|---|---|---|---|---|
| Active area_B | 1916 | 1408 | 2116 | 1606 | 145 | 69 | 108.602871 | 10.092169 | 76 |
| Active area_Gb | 1916 | 1408 | 2116 | 1606 | 254 | 144 | 199.512700 | 13.637692 | 110 |
| Active area_Gr | 1916 | 1408 | 2116 | 1606 | 274 | 147 | 199.217222 | 14.095196 | 127 |
| Active area_R | 1916 | 1408 | 2116 | 1606 | 132 | 55 | 91.673434 | 9.353424 | 77 |
| Active area_Y | 1916 | 1408 | 2116 | 1606 | — | — | 156.818316 | — | — |

- Sample the center square patch of 5% image width

1/30sec, 8x AGC



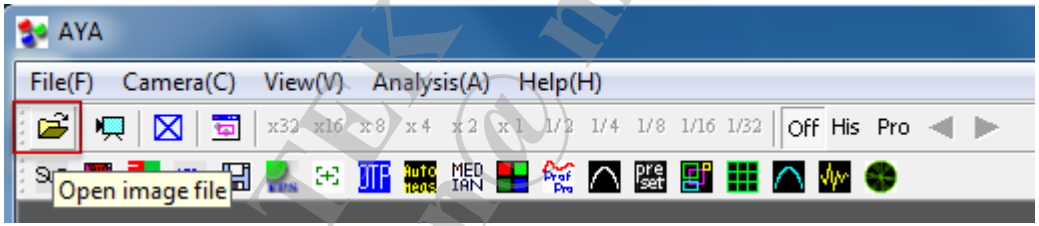
(RAW file Demosaiced by AYA)




(RAW Histogram from AYA)

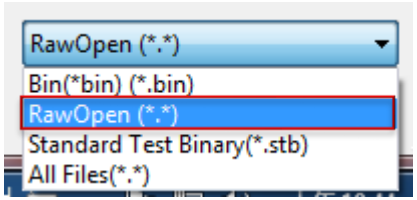
# RAW Noise - SNR Steps (1/7)

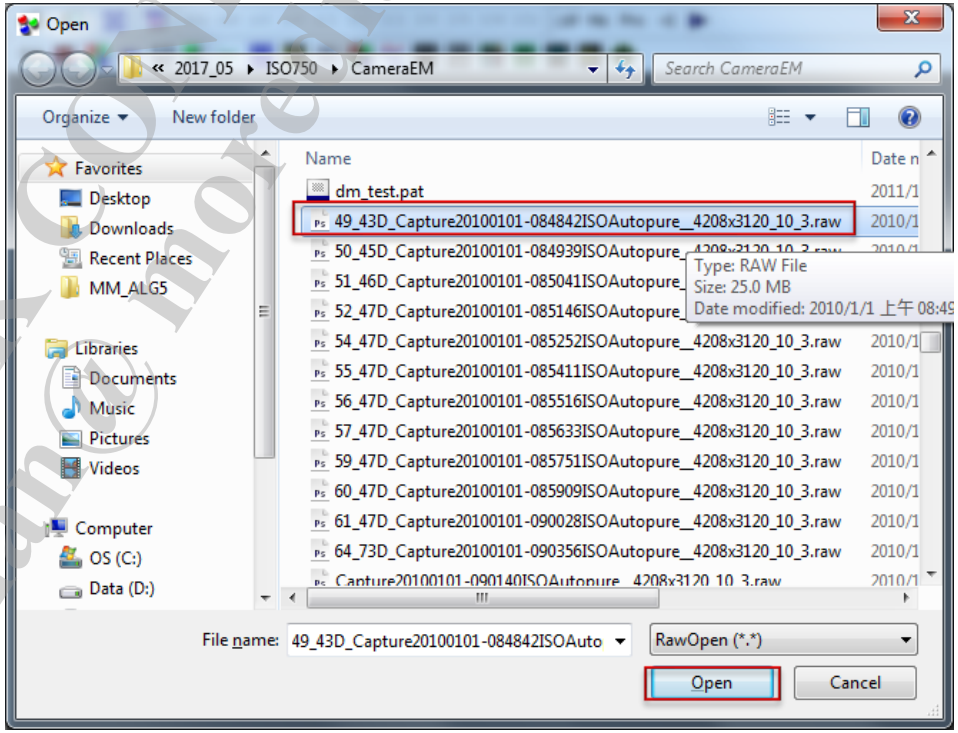
1. Launch AYA
2. Open image file



# RAW Noise - SNR Steps (2/7)

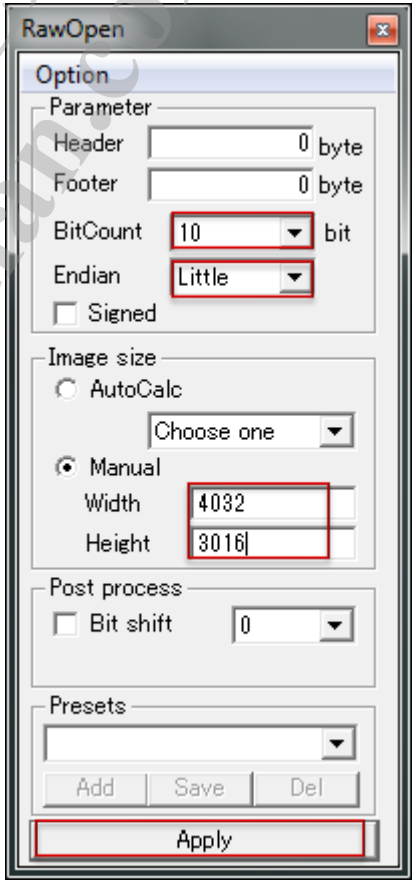
3. Select RAWOpen to browse .raw
4. Open RAW file



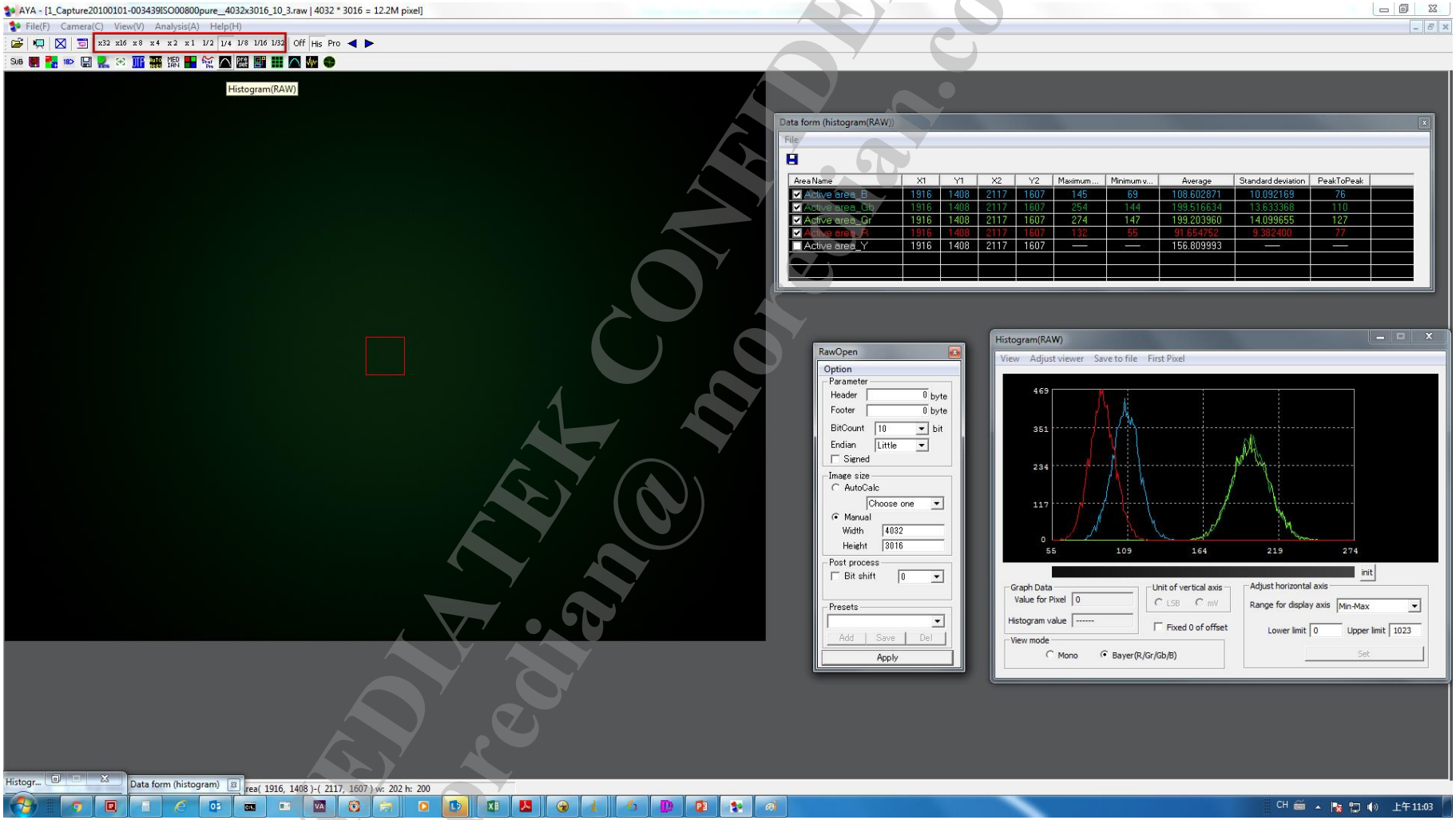
# RAW Noise - SNR Steps (3/7)

5. Select 10 BitCount
6. Select Little Endian
7. Keyin RAW width and Height
8. Push Apply



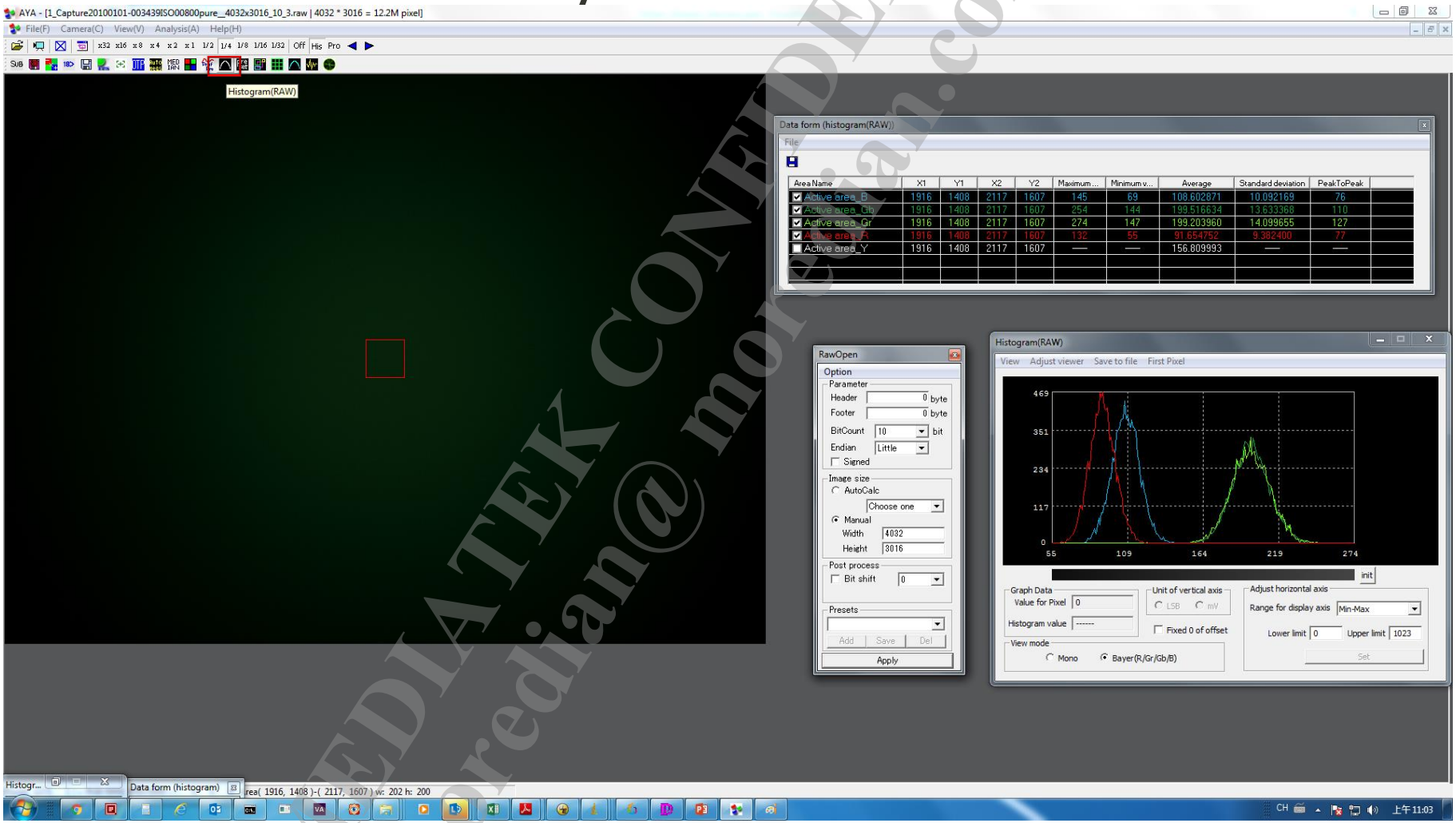
# RAW Noise - SNR Steps (4/7)

9. Select a Scaling Ratio for display (e.g. /4)



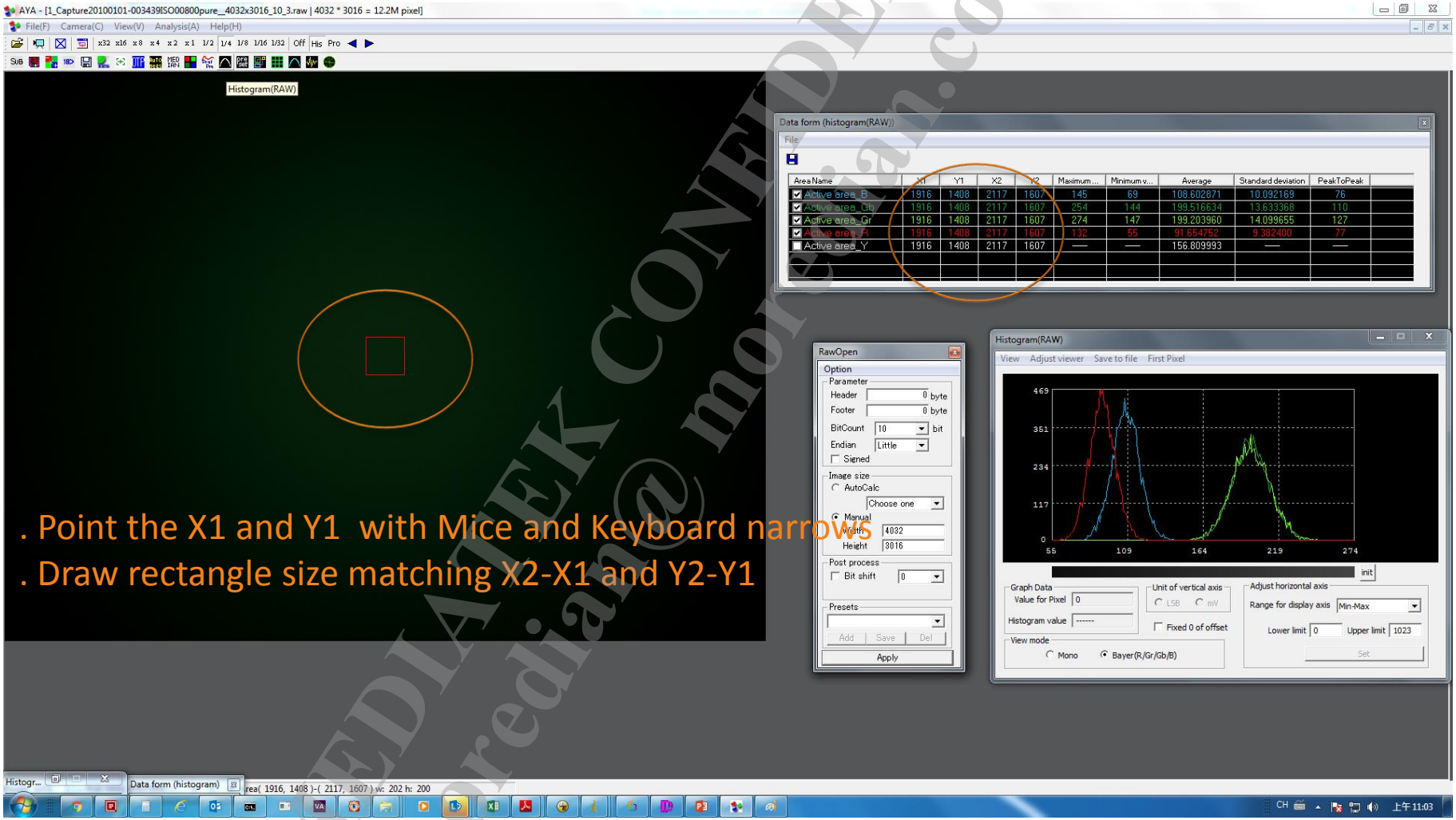
# RAW Noise - SNR Steps (5/7)

## 10. Push RAW History button



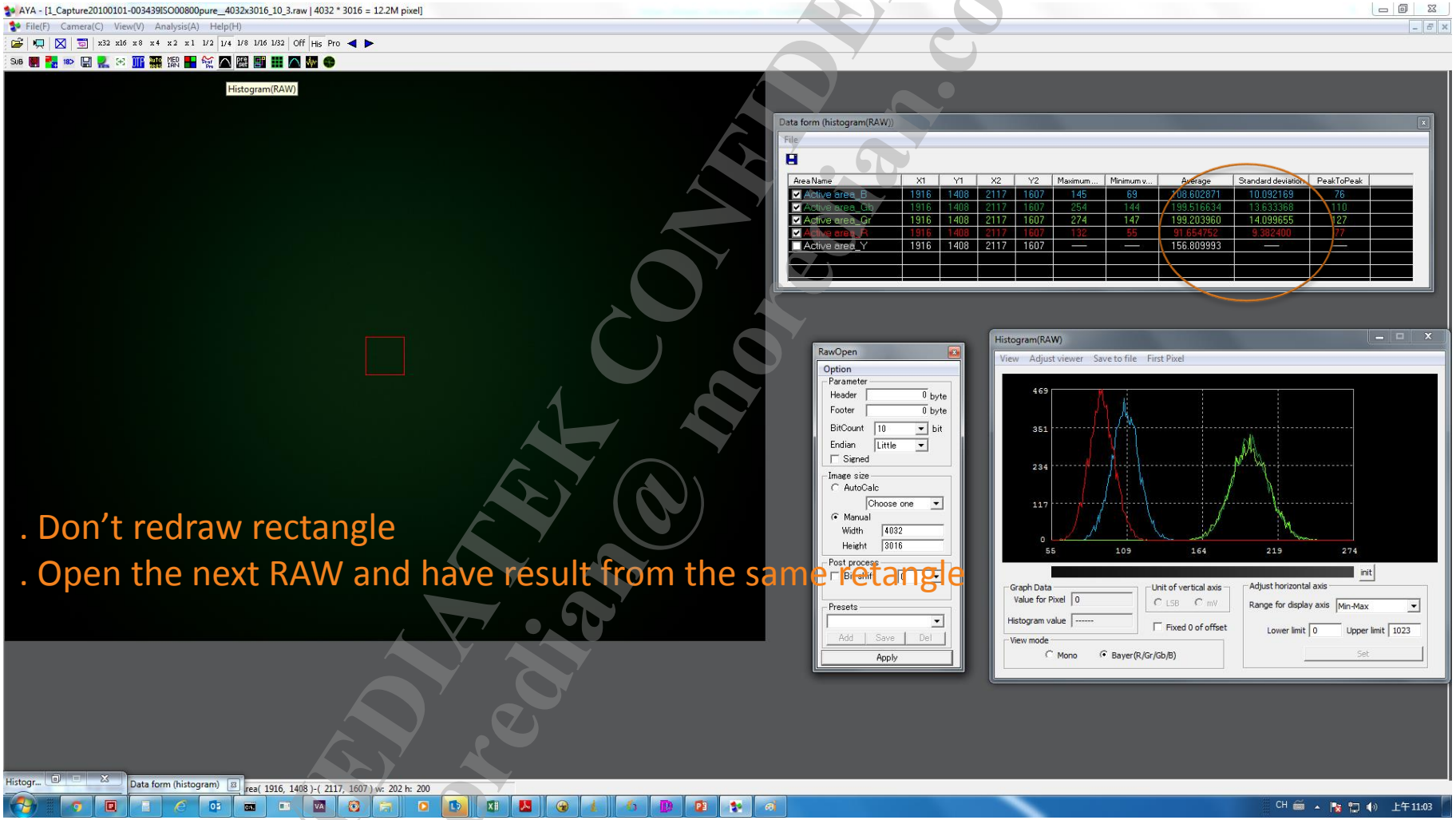
# RAW Noise - SNR Steps (6/7)

## 11. Draw a central square of 5% image width



# RAW Noise - SNR Steps (7/7)

- Get SNR by calculation of 20xlog(Average/Standard Deviation)



# RAW Noise - Example

- Check the pure RAW noise in Signal to Noise Ratio on each channels
- Example of the SNR selection

| Module 編號 | RAW SNR on Gr | | |
|---|---|---|---|
| | Average | Standard deviation | Main1 SNR |
| 1 | 199.49 | 13.62 | 23.31 |
| 2 | 195.52 | 14.31 | 22.71 |
| 3 | 190.48 | 13.43 | 23.03 |
| 4 | 199.32 | 13.68 | 23.27 |
| 5 | 196.86 | 13.45 | 23.31 |
| 6 | 193.05 | 13.66 | 23.01 |
| 7 | 190.16 | 13.62 | 22.90 |
| 8 | 192.30 | 13.53 | 23.05 |
| 9 | 201.12 | 13.96 | 23.17 |
| 10 | 191.67 | 13.45 | 23.08 |
| 11 | 189.54 | 13.51 | 22.94 |
| 12 | 198.11 | 13.69 | 23.21 |
| 13 | 196.45 | 13.48 | 23.27 |
| 14 | 190.55 | 13.57 | 22.95 |
| 15 | 200.25 | 13.97 | 23.13 |
| 16 | 197.35 | 13.88 | 23.06 |
| 17 | 197.56 | 13.85 | 23.09 |
| 18 | 187.52 | 13.54 | 22.83 |
| 19 | 193.12 | 13.70 | 22.98 |
| 20 | 192.27 | 13.49 | 23.08 |

- Pass Criterial:
  - ✓ Relatively Higher SNR value
  - ✓ No fixed-pattern noise
- Result:
  - ❖ Propose acceptable performance (Green cell in Ranking col)

# Summary - Capturing Conditions

| RAW | *Metric* | *Exposure Time* | *ISO (AGC)* | *Illuminant* | Chart | ROI |
|---|---|---|---|---|---|---|
| **Sharpness** | MTF50 | Normal AE | | D65 1000Lux | SFR Plus | Center<br>4 corners |
| **Noise** | SNR | 33 ms | 800 | LSB Day | Toward LSB | Central square of 5% image width |

# Appendix – Equipment List

| Item | Reference/Link |
| --- | --- |
| SFRPlus Chart | http://store.imatest.com/sfrplus-standard.html |
| Imatest | http://www.imatest.com/products/imatest-master/ |
| CCT tool | MediaTek CCT V2.0_DEV_xxxx.xx.rar |
| RAW Analyzer (SNR tool) | AYA, DevWare, or Panther |
| LSB-111 (SNR Chart) | (take central square of 5% image width as SNR ROI) |


*everyday genius*

INTERNAL USE

# III. Basic tuning verify

CONFIDENTIAL B

# MTK 3A/LSC verification test

Version: V1.0
Release date: 2017-05-12

# Document Revision history

| Revision | Date | Description |
|---|---|---|
| V1.0 | 2017-05-12 | • First version |
| | | |

# Overview

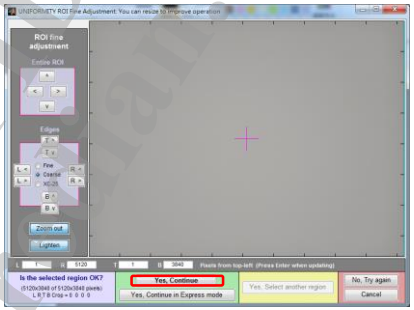
- 3A/LSC verification test
  - Lens shading correction
  - Auto exposure and contrast
  - Auto white balance
  - Auto focus

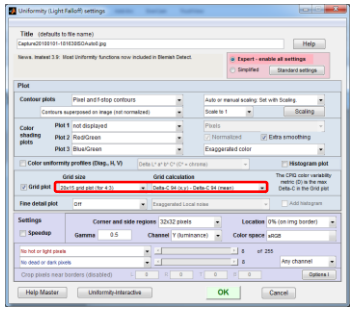
# Lens shading correction

- Luminance/Color uniformity test
  - Test goal:
    - check the luminance and color uniformity in different light conditions..
  - Test requirements:
    - D65, CW, TL84, A and H from Spectra Light conditions and DNP lightbox.
    - Grey chart 18%, Diffuser and Imatest software.
    - Repeat 3 images.
  - Test metric:
    - D65/DNP: Y shading > 75%, Color shading ΔC(mean) < 5
    - CW, TL84, A and H: Y shading > 65%, Color shading ΔC(mean) < 5

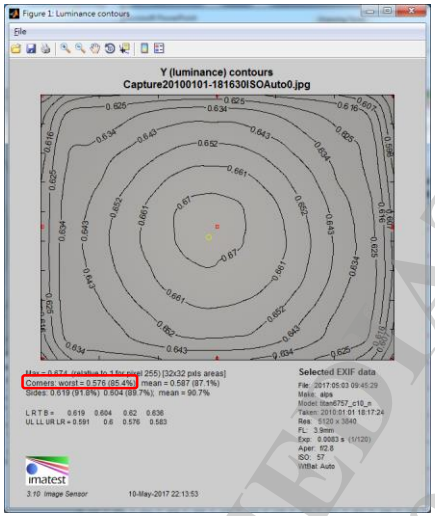
# Lens shading correction

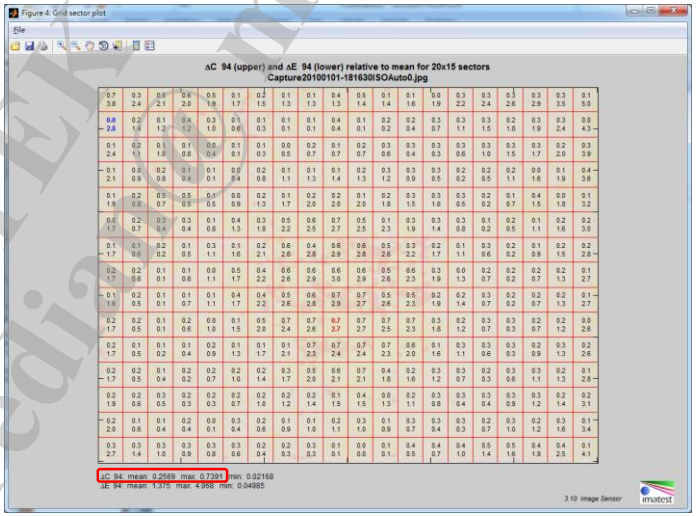
- Imatest software
  - Input images:



  - Results:

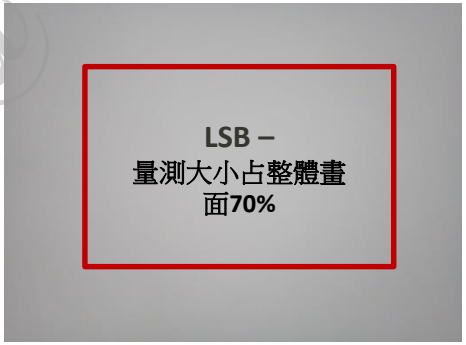


# Auto exposure and contrast

- Auto exposure target test
  - Test goal:
    - check the correct behavior of the exposure algorithm (if it reaches the target exposure.)
  - Test requirements:
    - LSB machine LV5~14, target phone (optional.)
    - Repeat 3 images.
  - Test metric:
    - Measure central 70% luminance value Y, 140<Y<220.
    - Measure central 70% luminance value Y, Target phone Y +/- 20 (optional.)


TSUBOSAKA LSB-111T2/B Light Source



# Auto exposure and contrast

- Contrast test
  - Test goal:
    - check the correct behavior of the exposure and contrast algorithm
  - Test requirements:
    - Daylight illuminants 700lux, target phone (optional.)
    - Q14 chart (occupied 70% FOV in width)
    - Repeat 3 images.
  - Test metric:
    - Measure Q14: patch1 Y>245,
      patch2~19 decreasing progressively,
      patch20<22.5
    - Measure Q14: patch1~5 target phone Y +/- 10,
      patch6~15 target phone Y +/- 15,
      patch16~18 target phone Y +/- 10,
      patch19~20 target phone Y +/- 5 (optional.)

# Auto white balance

- Auto white balance accuracy and stability test
  - Test goal:
    - check the white balance algorithm accuracy and stability
  - Test requirements:
    - Gretag Macbeth color checker (70% FOV in width)
    - D65, CW, TL84, A and H from Spectra Light conditions
    - Repeat 10 images.
  - Test metric:
    - Measure grey patch21-22 by saturation and hue, S=[max(R,G,B)-min(R,G,B)]/max(R,G,B), H(defined as following formula.)
    - Measure ΔS = max(S1~S10) – min (S1~S10)

      D65: S<0.08, ΔS<0.03

      TL84: S<0.10, ΔS<0.03

      CW: S<0.10, ΔS<0.03

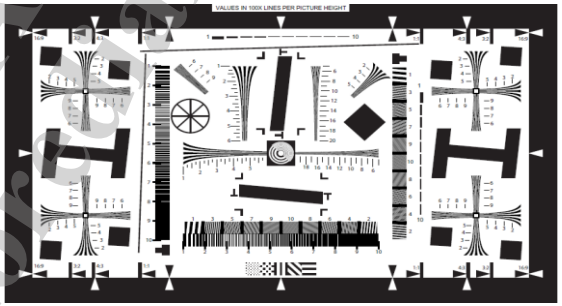
      A: 0.15<S<0.20, 15<H<35, ΔS<0.03

      H: 0.20<S<0.30, 15<H<35, ΔS<0.03

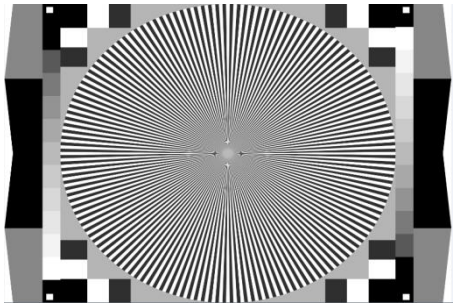
$$h = \begin{cases} 0^\circ & \text{if } max = min \\ 60^\circ \times \frac{g-b}{max-min} + 0^\circ, & \text{if } max = r \text{ and } g \geq b \\ 60^\circ \times \frac{g-b}{max-min} + 360^\circ, & \text{if } max = r \text{ and } g < b \\ 60^\circ \times \frac{b-r}{max-min} + 120^\circ, & \text{if } max = g \\ 60^\circ \times \frac{r-g}{max-min} + 240^\circ, & \text{if } max = b \end{cases}$$

# Auto focus

- Auto focus test
  - Test goal:
    - check the correctness of Auto focusing result
  - Test requirements:
    - Daylight illuminants 700 lux for CAF/TAF and 20 lux for CAF.
    - ISO12233 chart at 60cm and 2m, Star chart at 10cm.
    - For CAF, 10 consecutive shoots and between shoots, the focus must be forced to different distance by moving camera. For TAF, 10 consecutive shoots and between shoots, the focus must be forced to re-focus at the touch ROI (the center of the chart.)
  - Test metric:
    - Take 1 image by AF full scan as ground truth image.
    - Check the test images if any following failure happens:
      - Star chart focus failure: blur circle radius is 10% larger than the ground truth image.
      - ISO12233 chart focus failure: resulting line pair number is 20% smaller than the ground truth image.
      - AF search failure: AF cannot stop, AF cannot trigger, AF damping, AF overshot…



ISO 12233 chart



Star chart


*everyday genius*