MT6757P MFNR Manual

2017/03

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- MFNR2.0 Flow Introduction
- MFNR2.0 Tool Operation Guide
- MFNR2.0 Tuning Guide

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- **MFNR2.0 Flow Introduction**
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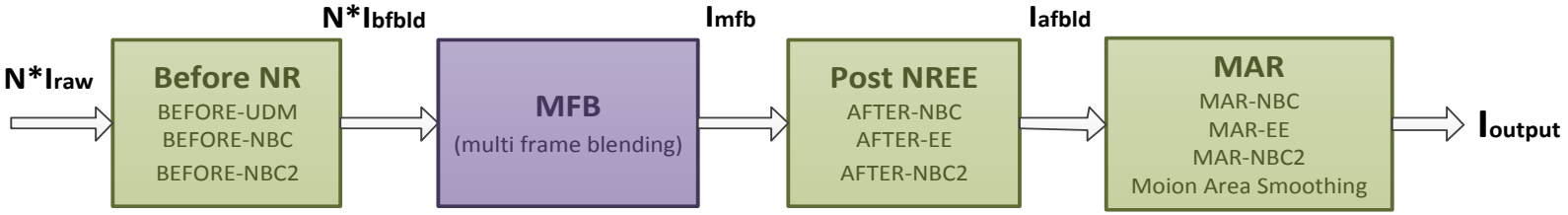
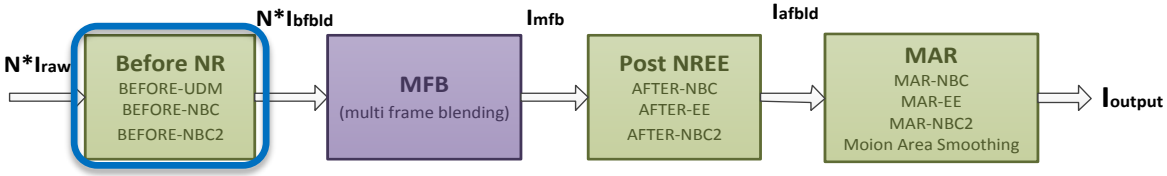
MFNR Flow Introduction

- **Objective**
  - Reduce luma/chroma noise by multi-frame blending
  - V2.0 new feature: motion area noise refinement (MFB/MAR)
- **Flow**



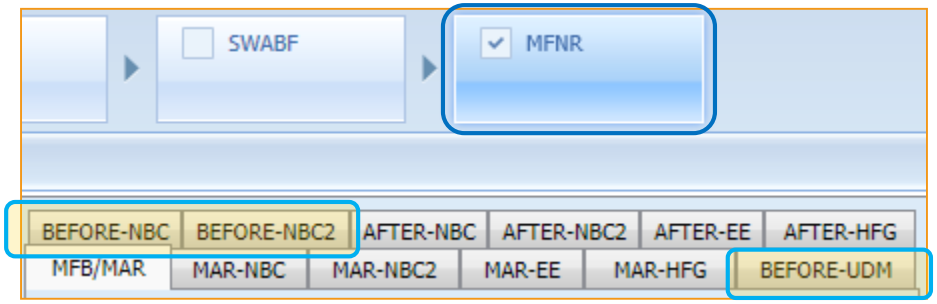
N*Iraw:	Input RAW files. In MT6757P, N=2~6
N*Ibfbld:	Images prepared to do multi-frame blending
Imfb:	Single blended Image
Iafbld:	Image after post-processing
Ioutput:	Image after motion area refinement

MFNR Flow Introduction

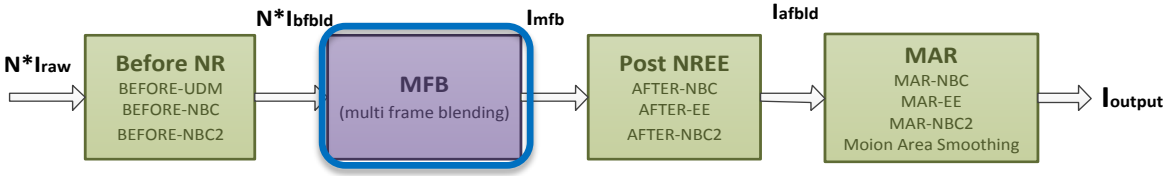


1. Before NR

- Convert RAW to YUV format
- Noise pre-reduced to fit into MFB's capacity
- Remove impulse noise and bad pixels
- Relative Registers:
  - MFNR→BEFORE-UDM
  - MFNR→BEFORE-NBC
  - MFNR→BEFORE-NBC2



MFNR Flow Introduction

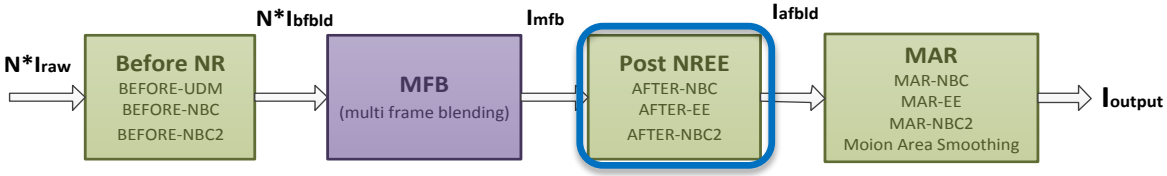


2. MFB (Multi-Frame Blending)

- Compound motion-compensated frames into one frame
  - Reduce noise without losing details
  - Work on both luma and chroma noise

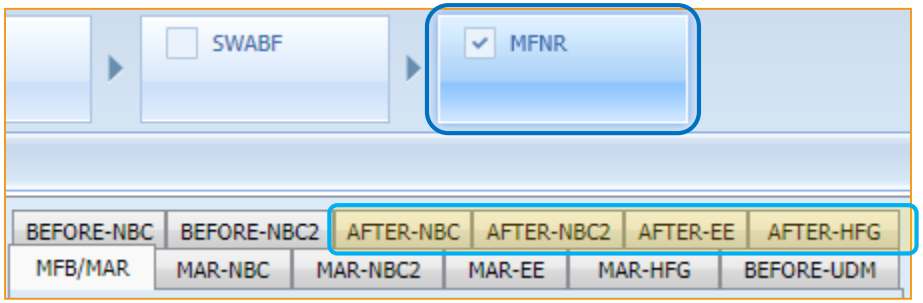
- Relative Registers:
  - MFNR → MFB/MAR

MFNR Flow Introduction

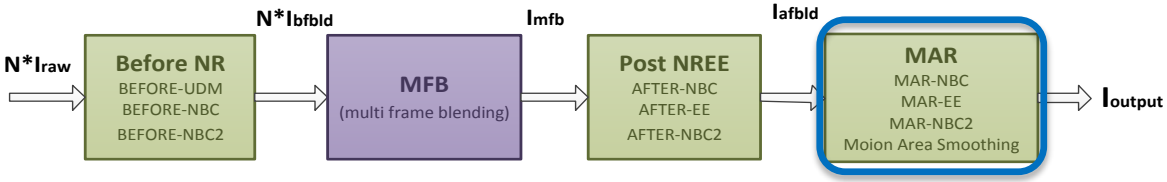


3. ISP Post NREE

- Apply AFTER-NBC/EE/NBC2/HFG:
  - Reduce low-frequency noise in advance
  - Improve image sharpness
  - Add random fine noise, for boosting visually clarity
- Relative Registers:
  - MFNR → AFTER-NBC
  - MFNR → AFTER-EE
  - MFNR → AFTER-NBC2
  - MFNR → AFTER-HFG

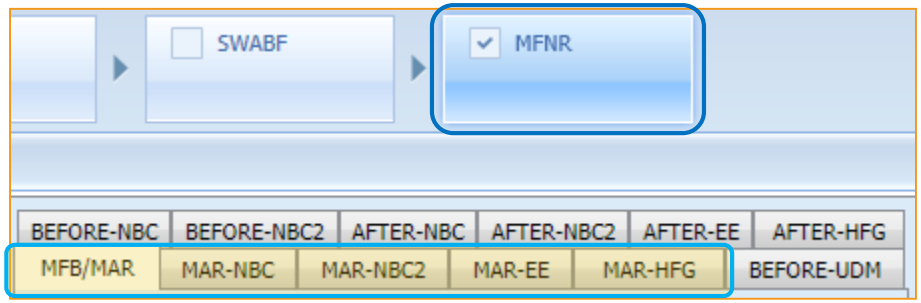


MFNR Flow Introduction



4. Motion Area Refinement

- Apply stronger NR against motion area
  - Remove motion occlusion noise left in MFB stage
  - Improve visual continuity around the boundary of motion and static areas
- Relative Registers:
  - MFNR → MFB/MAR
  - MFNR → MAR-NBC
  - MFNR → MAR-EE
  - MFNR → MAR-NBC2
  - MFNR → MAR-HFG



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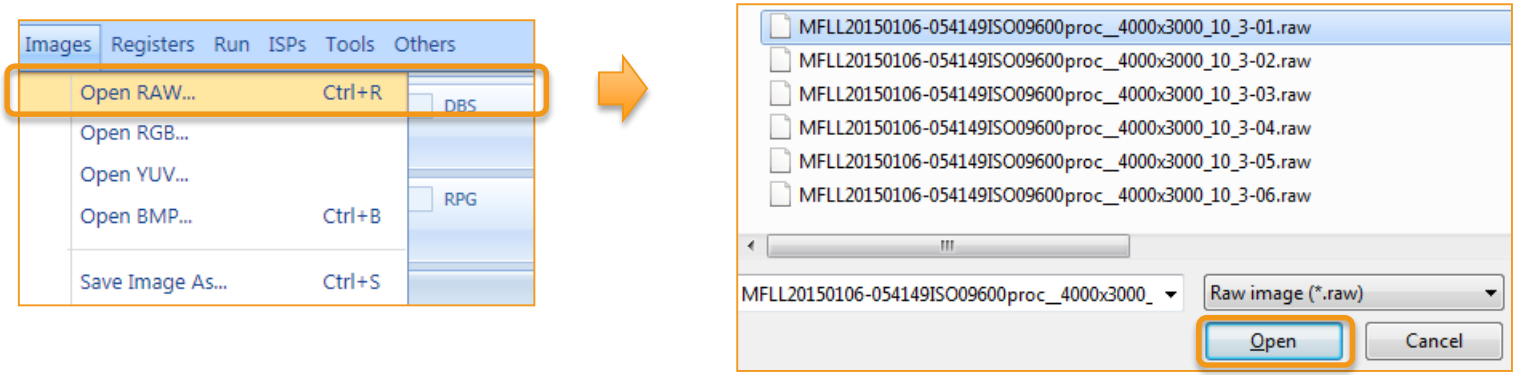
- **MFNR2.0 Tool Operation Guide**
- MFNR2.0 Tuning Guide

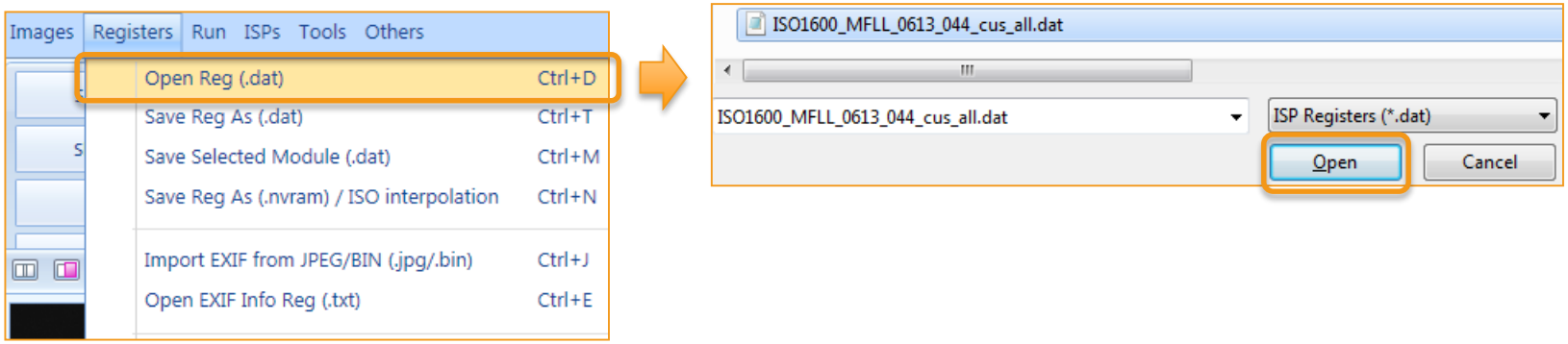
MFNR Tool Operation Guide

- Step1 (I): Load RAW files
  - Hot Key: CTRL + R
  - Make sure that all MFNR RAW files share the same name, followed by a serial number
  - Only the first one(*-01.raw) needs to be selected
  - JPG and SDBLK with same file name will also be loaded automatically



MFNR Tool Operation Guide

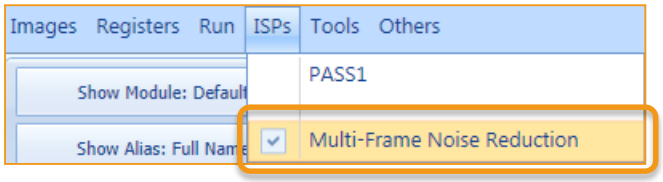
- Step1 (II): Load DAT Settings
  - Hot Key: CTRL + D
  - For loading pre-saved DAT file, make sure RAW is loaded at first



MFNR Tool Operation Guide

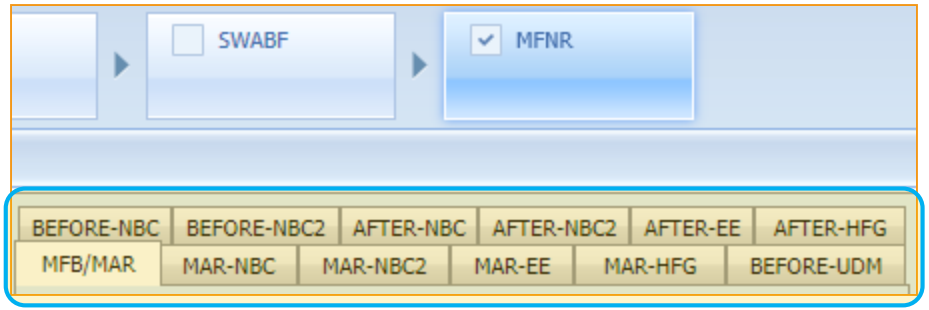
- Step2: Ensure MFNR flow is enabled
  - Menu -> ISPs -> ensure ”Multi-Frame Noise Reduction” is checked

    (If RAW is shot in MFNR mode, it’ll auto-checked after RAW/JPG loaded, only confirmation needed)



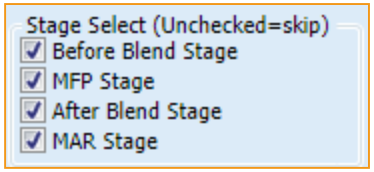
MFNR Tool Operation Guide

- Step3: Registers Checking/Tuning
  - MFNR related parameters are congregated into 12 tabs in MFNR page (Please refer following ”MFNR Tuning Guide” section for tuning)

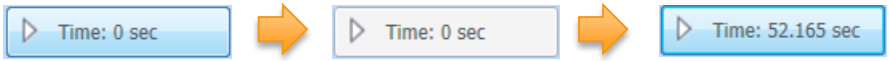


MFNR Tool Operation Guide

- Step4(I): Full Simulation
  - In MFB/MIX tab, make sure all MFNR stages are checked.



  - Press button to run simulation (Hot Key: F2)

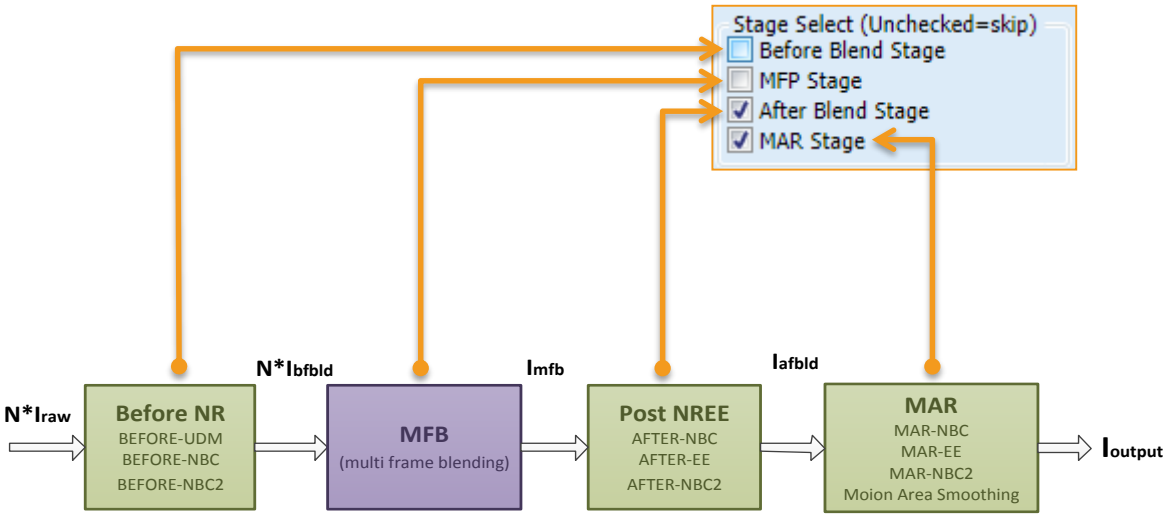
  - Check the running status: 

Before Run **Running** **Run Finished**

  - It takes about 4~12 minutes for full MFNR simulation.

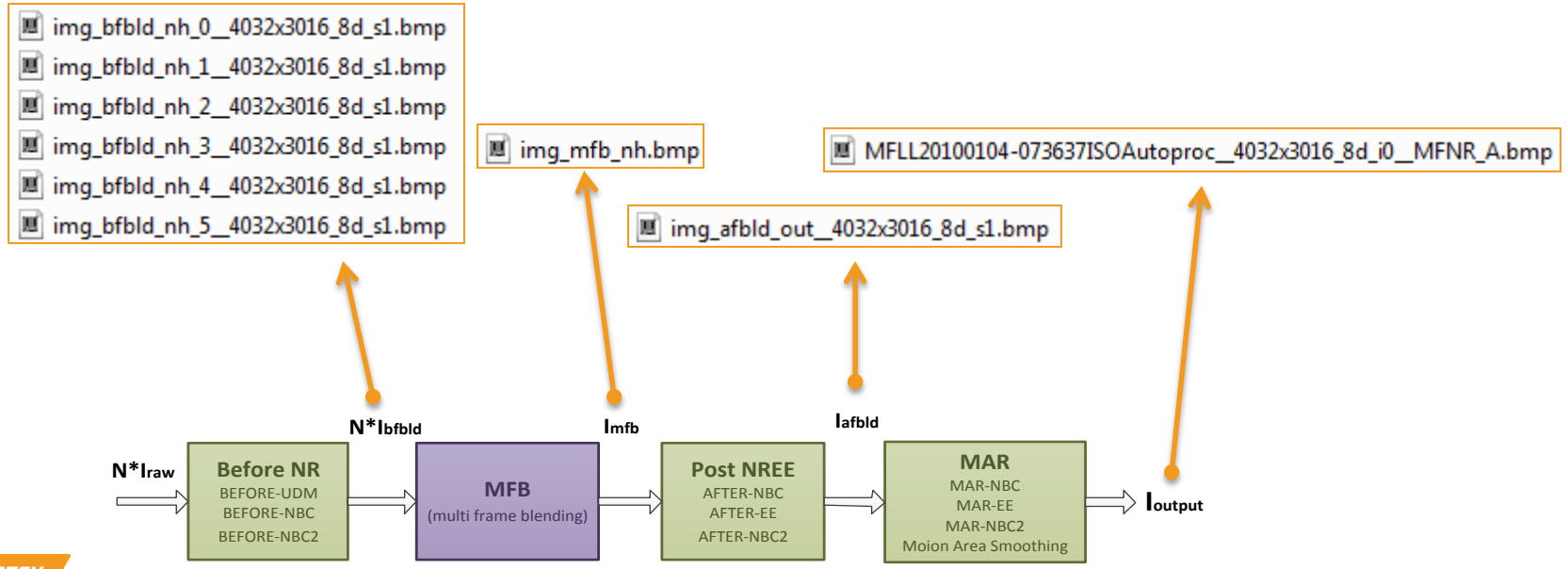
MFNR Tool Operation Guide

- Step4(II): Partial Simulation
  - Once full simulation is done, some stages can be skipped in next run if no register in the stages been changed.
    - **Ex:** If only AFTER-NBC/EE module are tuned since previous run, Before/ MFB can be skipped in next run.



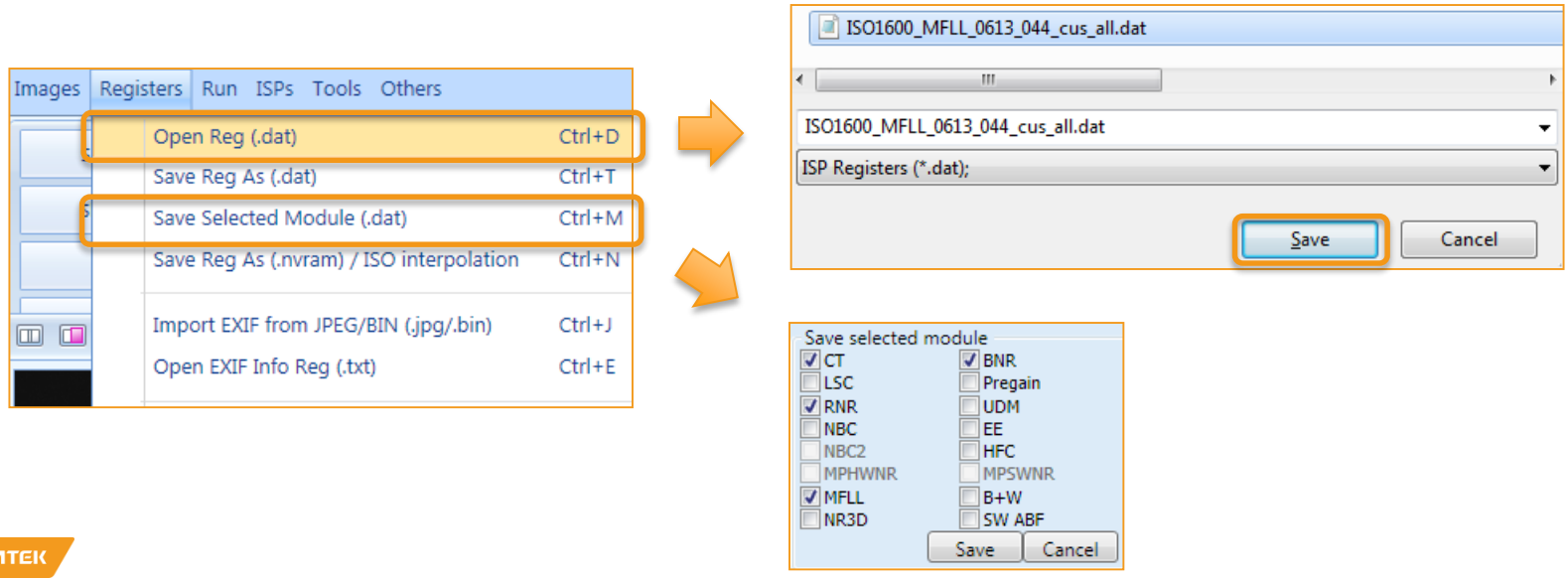
MFNR Tool Operation Guide

- Step5: Result Images Checking
  - Results are saved in “Results\” folder located in the same folder as the RAW files
  - Following bitmap files would be generated after full simulation:



MFNR Tool Operation Guide

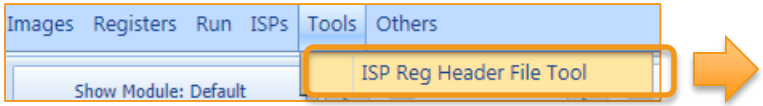
- Step6: Save tuning result as DAT file
  - For next time tuning & simulation
  - Hot Key: CTRL + T
  - Can also choose to save MFNR related modules only. (CTRL + M)
  - Suggest to name DAT file with ISO/camera sensor/IC for recognizing

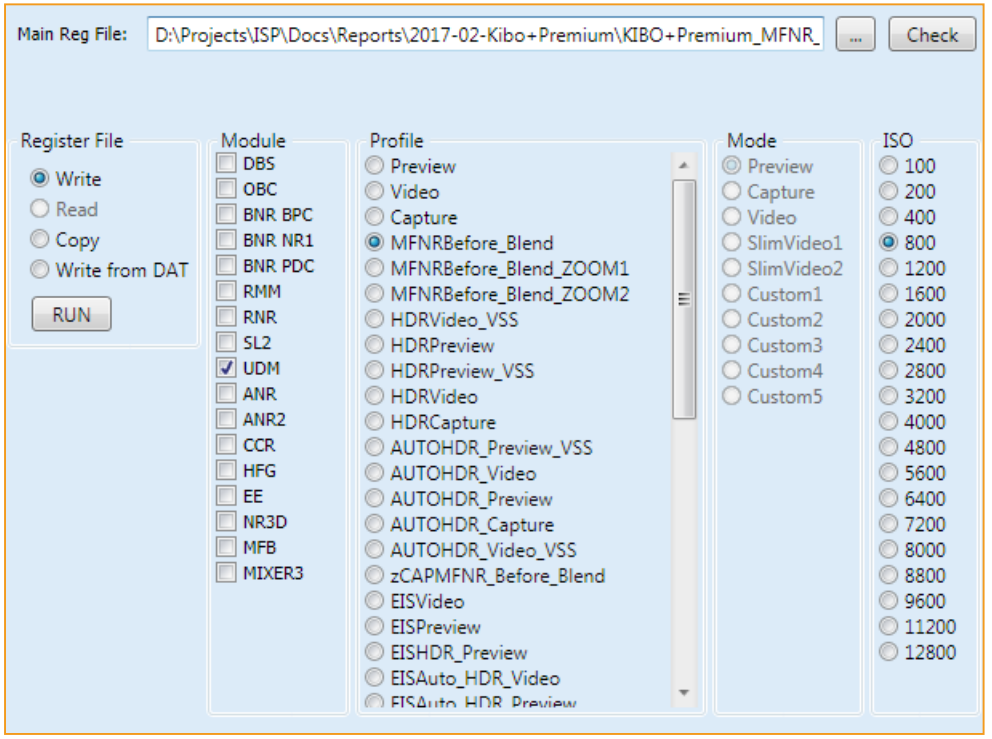


MFNR Tool Operation Guide

- Step7: Merge Settings to “camera_isp_regs_XXX.h”

  Please refer ”Guideline_ISP_Reg_Header_File_Tool.pptx”





MFNR Tool Operation Guide

- Step8: Set frame-number in “camera_feature_para_imxXXXmipiraw.h”
  - Set *capture_frame_number = blend_frame_number = 6* (max. frames)
  - Set *mfll_iso_th* = minimum MFNR enable ISO
  - There are 7 ISO thresholds for MFB frame-number mapping. Frame_num1~7 are individually mapping to iso_level1~7

```
// Gives N, for capturing N frames
capture_frame_number        :   6,
// Gives N, for N-frame blending. E.g.: N = 6, 6-frame blending, do blending 5 times.
blend_frame_number          :   6,
// Give 0 or 1, 0 for half size MC, 1 for full size MC
full_size_mc                :   1,
memc_bad_mv_range           :   255,
memc_bad_mv_rate_th         :   12707,
// The threshold of doing MFB or not
mfll_iso_th                 :   200,
// iso range for adaptive frame number mechanism
iso_level1                  :   200,
iso_level2                  :   300,
iso_level3                  :   400,
iso_level4                  :   600,
iso_level5                  :   800,
iso_level6                  :   2000,   // reserved for extension
iso_level7                  :   2000,   // reserved for extension
// at least to set blend frame number >= 2
frame_num1                  :   2,
frame_num2                  :   3,
frame_num3                  :   4,
frame_num4                  :   5,
frame_num5                  :   6,
frame_num6                  :   6,
frame_num7                  :   6,      // reserved for extension
```

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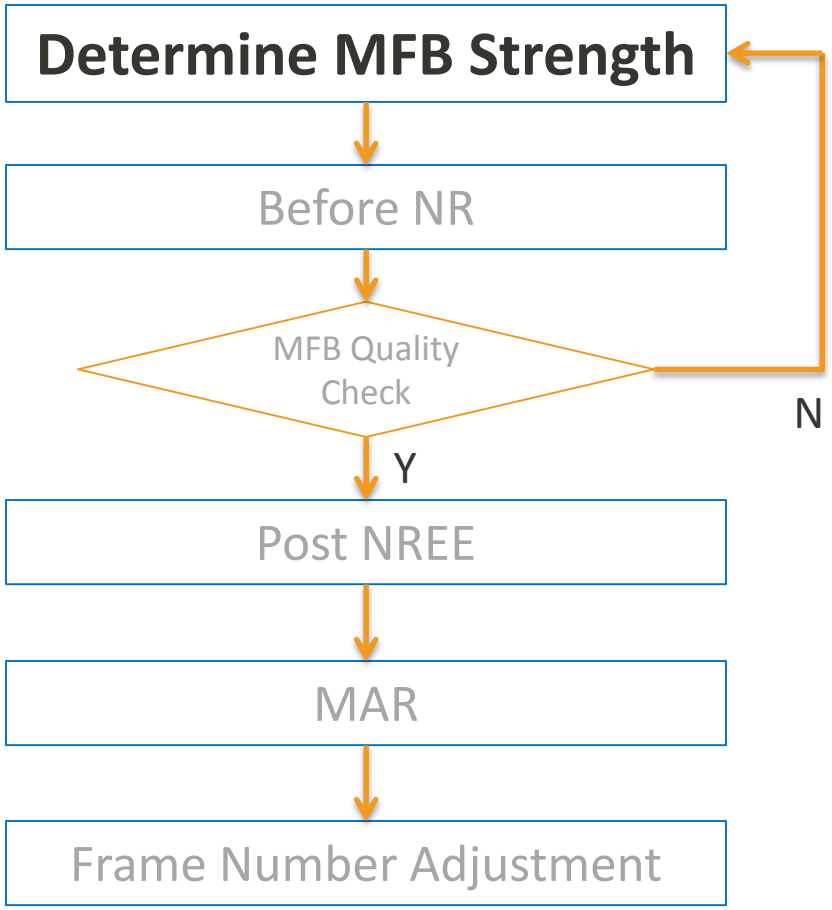
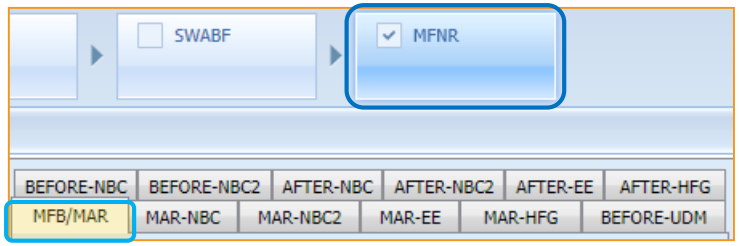
- **MFNR2.0 Tuning Guide**

MFLL Tuning Guide





MFB Strength Decision

- Proper MFB strength is around 20~28

Lower Strength:

Weak NR result in static area

MFB Strength = 8

Proper Strength:

(MAR will take care of the motion noise)

MFB Strength = 24

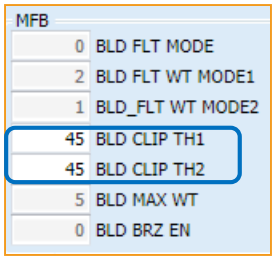
Higher Strength:

Ghost side-effect in motion area

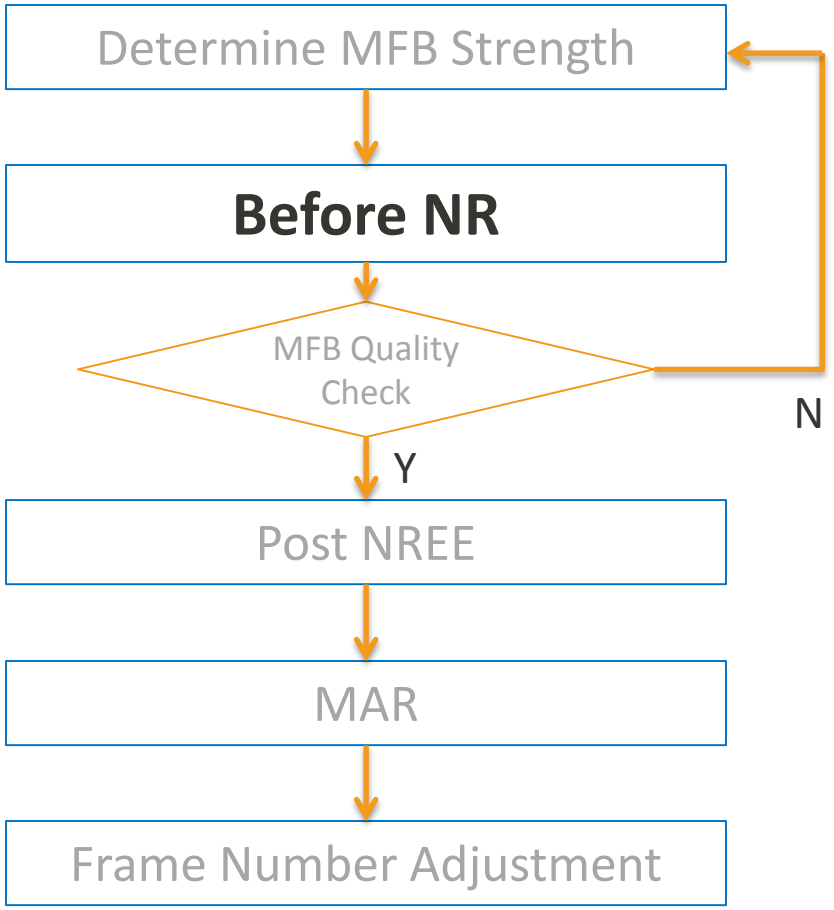
MFB Strength = 40

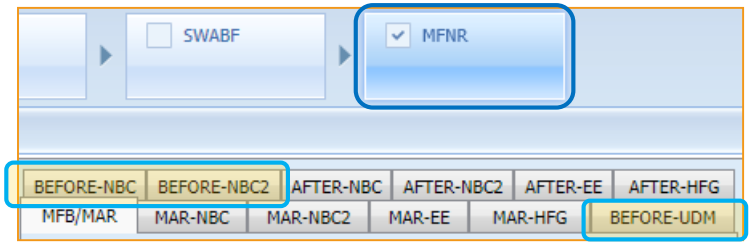
MFB Strength Decision

- Set CLIP_TH1& CLIP_TH2 after MFB strength decided.
- CLIP_TH1 = CLIP_TH2 = (MFB_Strength + 8)*1.2



MFNR Tuning Guide





Before NR - STEP 1

- Calculate proper I_{bfbld} noise STD by MFB Strength

$$STD(I_{bfbld}) \approx \frac{MFB_Strength}{3}$$ (Consider noise/details balance)

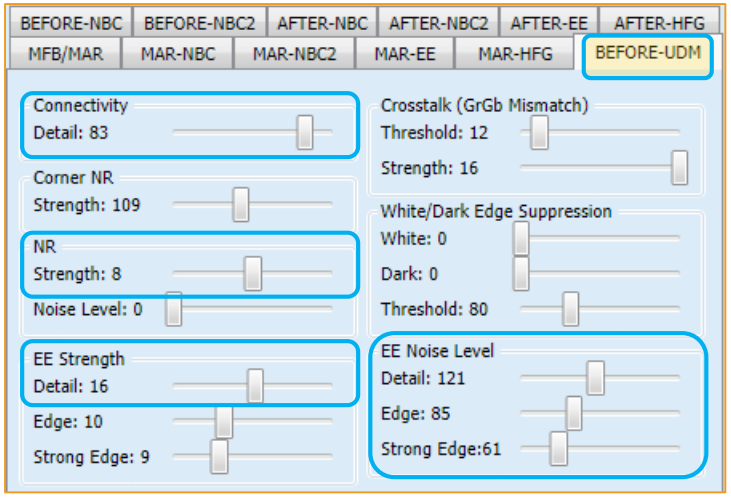
EX:

- *MFB_Strength=20* => $STD(I_{bfbld}) = 20/3 \approx 6.67$
- *MFB_Strength=28* => $STD(I_{bfbld}) = 28/3 \approx 9.33$

- Tune BEFORE-UDM & BEFORE-NBC to fit I_{bfbld} into the STD limitation.

Before NR -
STEP2: UDM

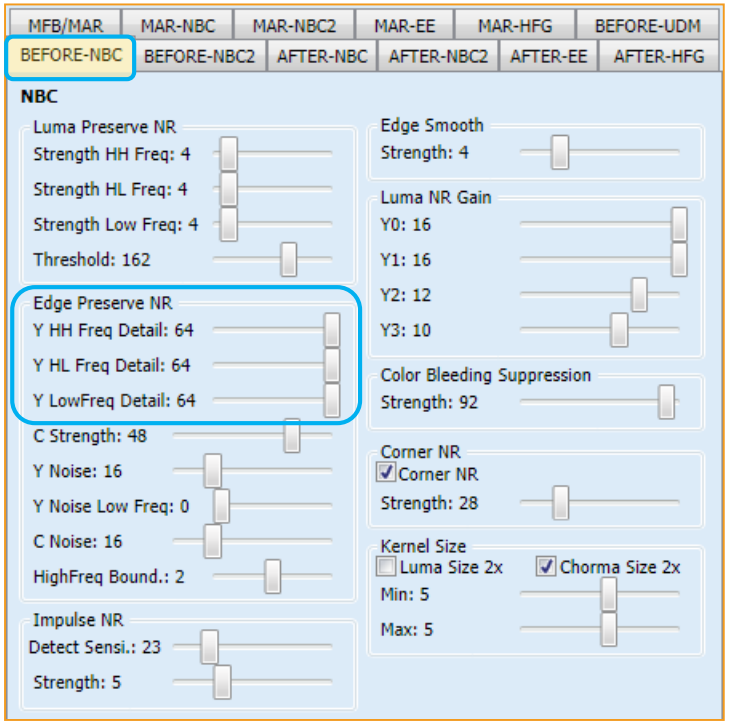
- Please refer DM3.0 tuning guide for register tuning.
- When ISO increases:
  - Dial “EE Noise Level” up
  - Dial “Connectivity Detail” down
  - Dial “EE Strength-Detail” down
  - Dial“NR Strength” up



Before NR - STEP 3

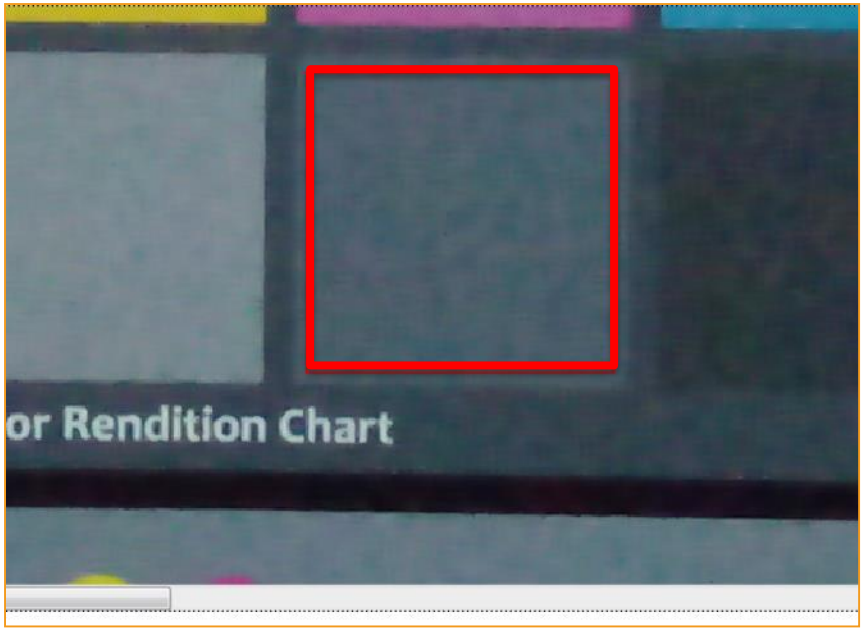
- Before tuning BEFORE-NBC, set **Y HH/HL/L Detail** =64 to measure STD with NR off
- If the STD meets the formula in STEP1, no need to enable BEFORE-NBC

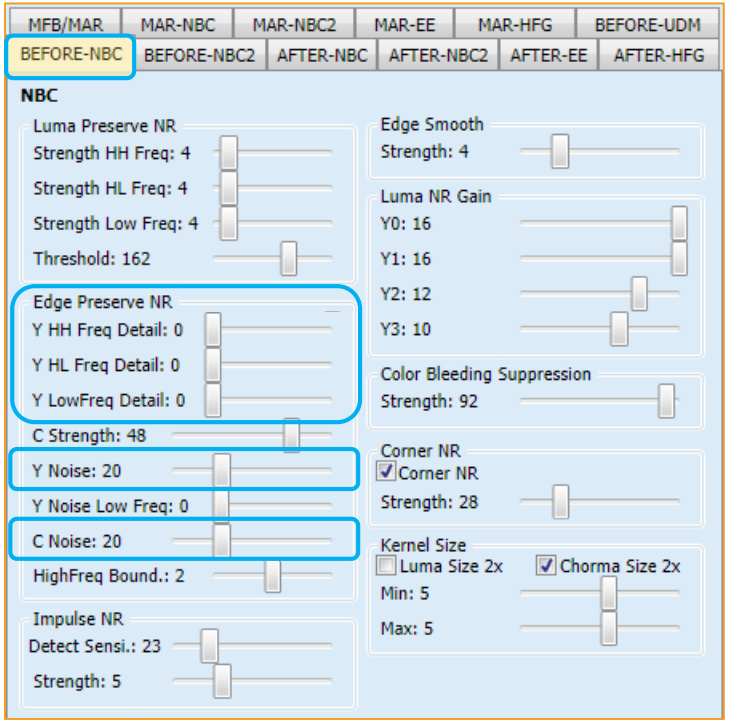
Stddev:(Y,Cb,Cr)=(9.27, 0.81, 0.47)



Before NR - STEP 4

- Set **Y HH/HL/L Detail** =0 (no blend to source), for checking pure NR result
- Adjust **Y/C Noise** NR, ensure that noises in flat region are all cleaned (include impulse noises)

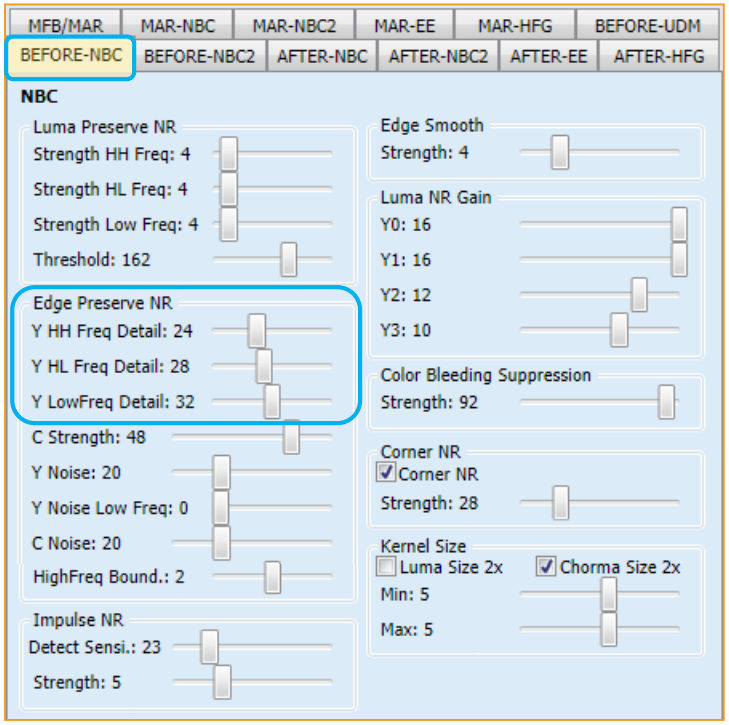




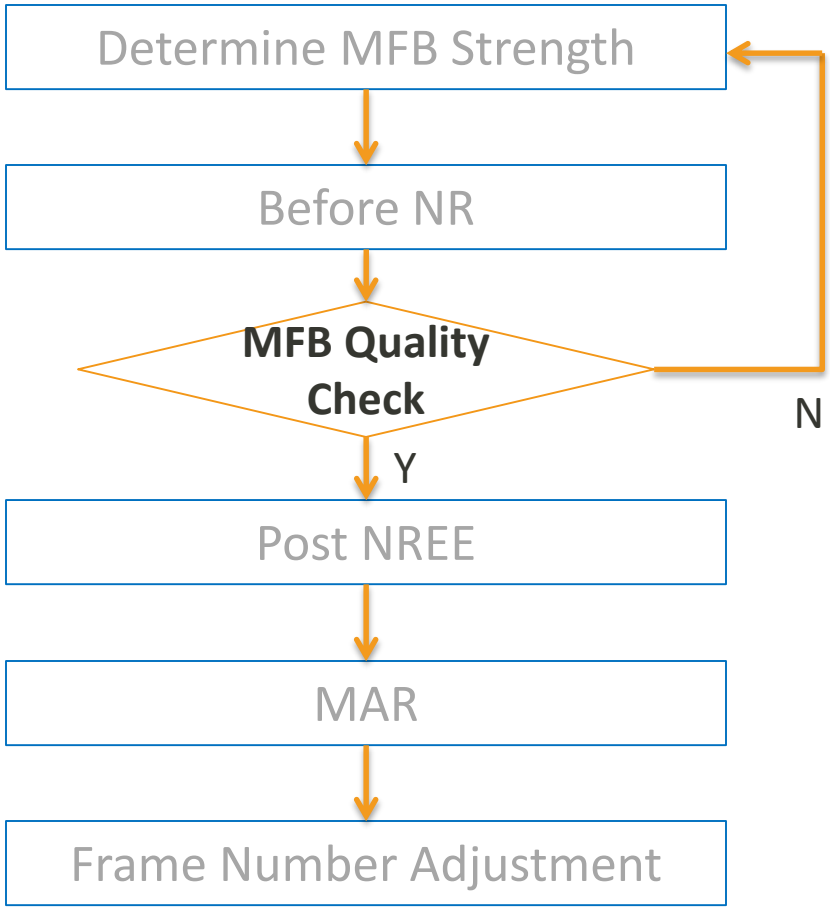
Before NR - STEP 5

- Increase **Y HH/HL/L Detail** to add noise/detail back, till the STD meets the requirement of STEP1 formula.

Stddev:(Y,Cb,Cr)=(5.70, 0.34, 0.07)



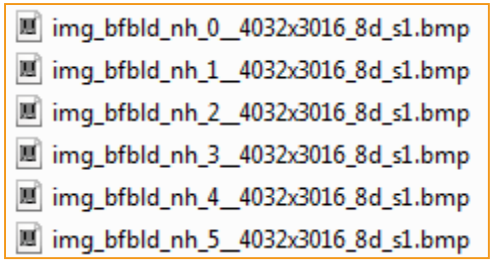
MFNR Tuning Guide



MFB Quality Check

Checkpoint:

- *Ibfbld*
  - Check if all images meets the STD requirement
  - Check if brightness/color/ISO of all images are consistent
  - Check mfnr_sim_log.txt, ensure base_idx makes sense

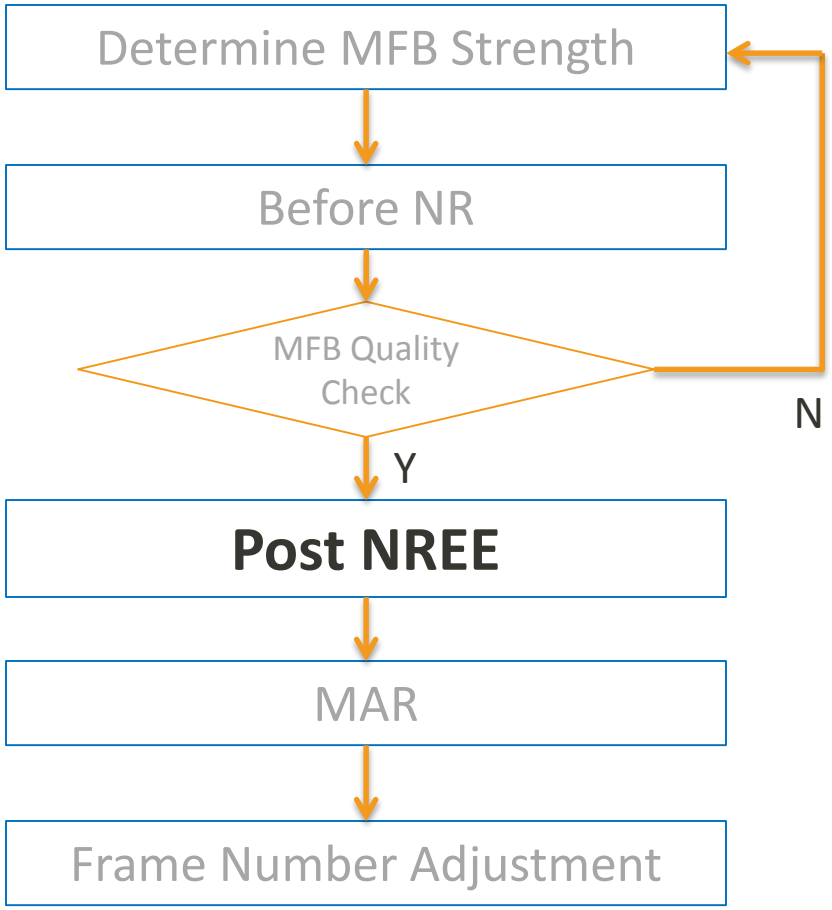


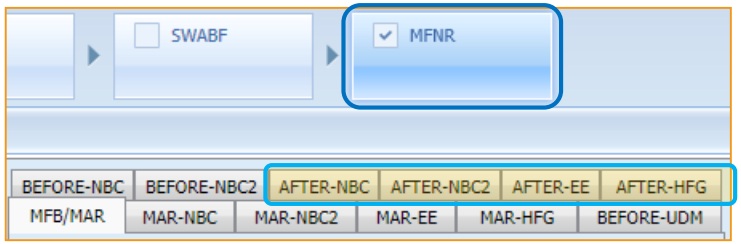
- *Imfb*
  - Ghost effect in motion area(kids, cars, sports, walkers, etc)
    - Decrease XXX_THH0~2 / Increase “n” value in MFB v2.0 Tuning Step2
    - Need to re-tune MFB/BeforeUDM/NBC by steps
  - Too much noise => Check the MFB weighting Map
    - Tune BEFORE-NBC/NBC2
    - Increase YL2_THH2
    - Noise in motion area can be ignore here, MAR will take care later
    - Stronger corner Noise => BEFORE_NBC_LCE_GAIN2~3 / BEFORE_UDM_SL_Y2
    - Some slighter noise can also be handled by AFTER-NBC later
  - Lack of details
    - Lower UDM N0 / Higher UDM HT/HD
    - If details exist, just a little blurry, it can be enhanced by AFTER-EE later

MFB Quality Check

- **Weighting Map (BLD_W_OU.bmp)**
  - Keep higher MFB weighting in static region (map pixel value = 32*frame_number)
    =>Adjust BEFORE-NBC/NBC2, higher YL2_THH2
  - Keep lower weighting in moving region (map pixel value -> 0)
    =>Lower YL2_THH0

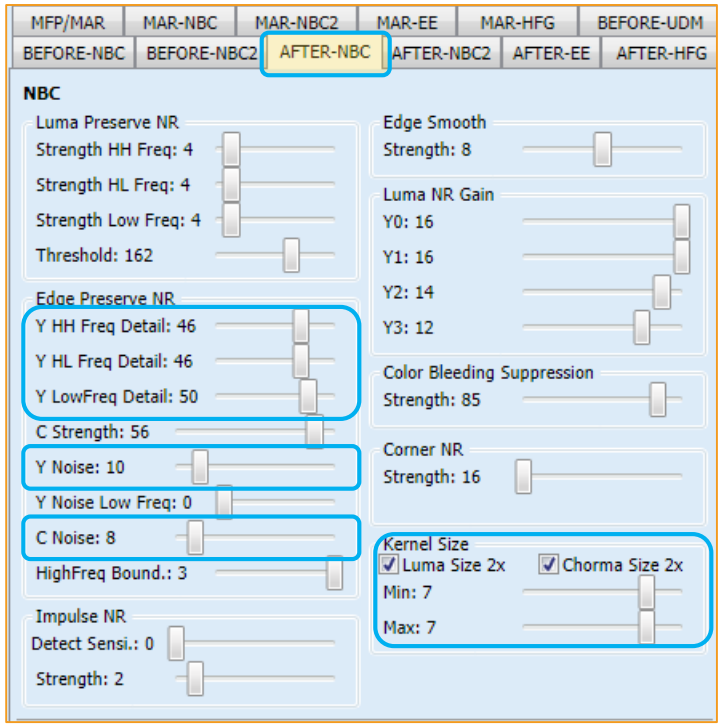
MFNR Tuning Guide





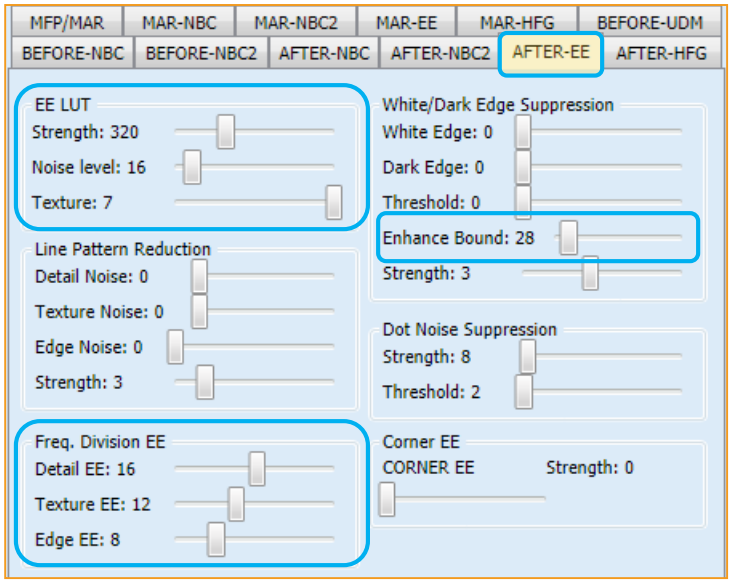
Post NREE - NBC

- Objective: STD in static area ≈ referenced photo
  - Similar to BEFORE-NBC tuning steps
  - **Y HH/HL/L Detail:** control noise level
  - **Y Noise / C Noise** should be smaller than BEFORE-NBC
- Reduce low-frequency noise
  - Raise **Kernel Size Min/Max**
  - Check **Luma/Chroma Size 2x**



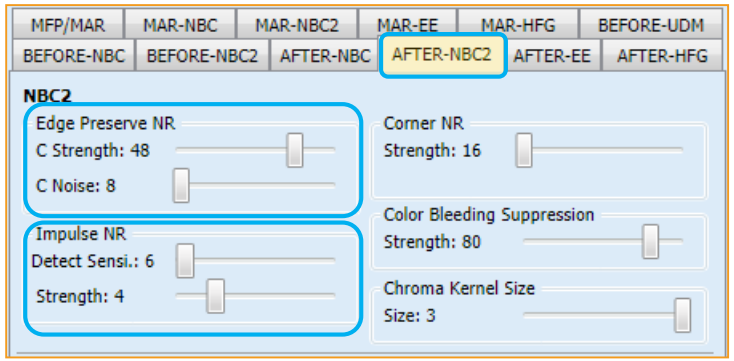
Post NREE - SEEE

- Objective: Final sharpness of edge and details ≈ referenced photo
  - By frequency: Adjust **Freq. Division EE**
  - By Edge index: Adjust **EE LUT**
- Suppress ringing side-effect
  - Dial down **Enhance Bound**
- Please refer [SEEE3.0 Tuning Guide] for advanced EE tuning



Post NREE - NBC2

- If still impulse noises left in static area(sometimes they are raised by AFTER-EE), alleviate them by **Impulse NR** in AFTER-NBC2



- Use **Edge Preserve NR** for low-frequency chroma noise reduction

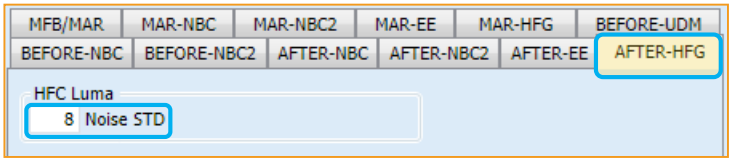
  (ultra-low frequency chroma noise can be taken care by later SWNR if needed)

Before AFTER NR/EE

(Check if Noise/Ghost been enhanced, Overshoot, Contrast, details)

Post NREE - HFG

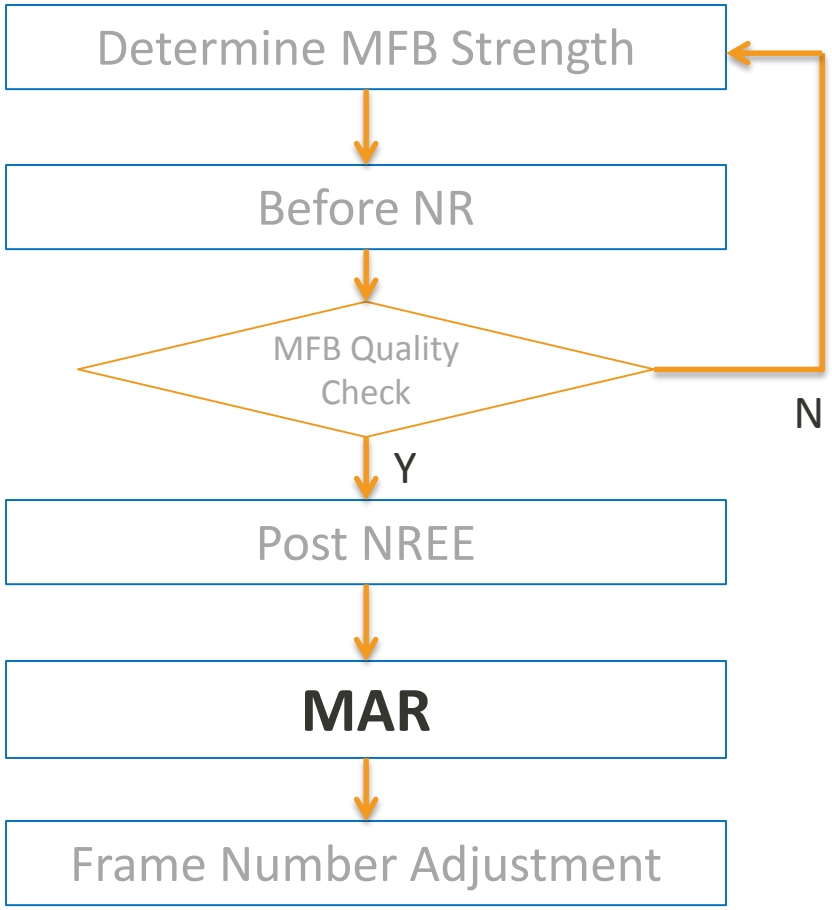
- Raise Noise STD to enhance visual clarity
  - Noise STD ≈ 0~16

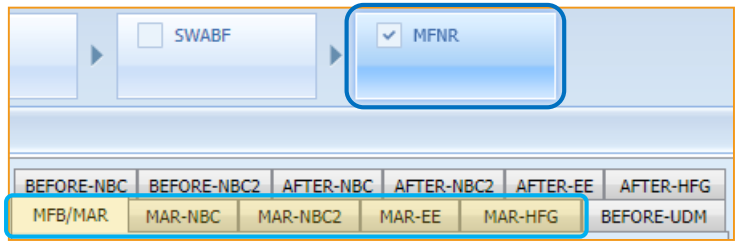


Noise STD = 0

Noise STD = 16

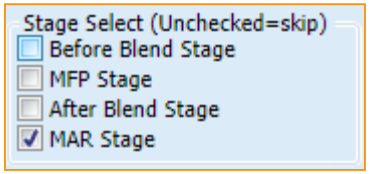
MFNR Tuning Guide





MAR Tuning

- **Goal:**
  - Motion noise left by MFB should be handled in MAR(Motion Area Refinement), to keep its noise level being consistent with the static area
- **Tuning Criteria:**
  - MAR NR/EE strength can be predicted by fine-tuned AFTER NR/EE setting
  - MAR-NBC/NBC2: check the motion noise level is similar to neighboring static area after MAR
  - MAR-EE: ≈ After-EE
- **Partial Run Setup:**

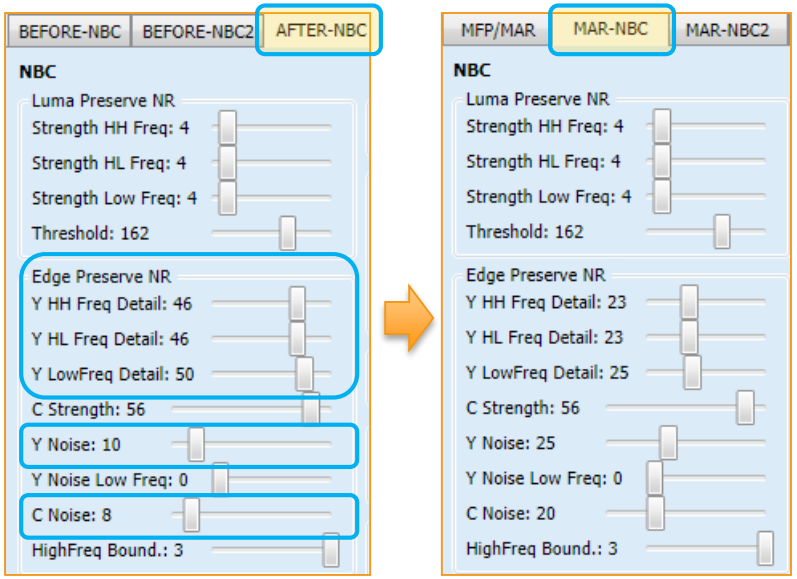


MAR – Tuning Criteria

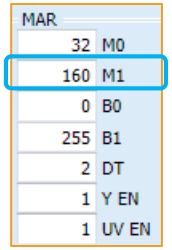
- MAR-NBC only works on motion area.
- Make sure STD of static and motion area are similar after MAR

MAR – Tuning

- MAR-NR Suggestion:
  - **Y/C Noise** ≈ (MFB FrameNum)^0.5 x [AFTER_NBC1 PTC/Y]
  - **Y HH/HL/L Detail** :
    - ≈ (0.3~0.5) x (AFTER_NBC1)
    - Adjust to align STD(**Ipost**)
  - Other parameter:
    - ≈ (AFTER_NBC1/2)



- MAR_M1
  - M1↑: Motion Noise↓;
    Details between motion & static area ↓
  - Suggest M1 value for 6-frame MFB: 96~160

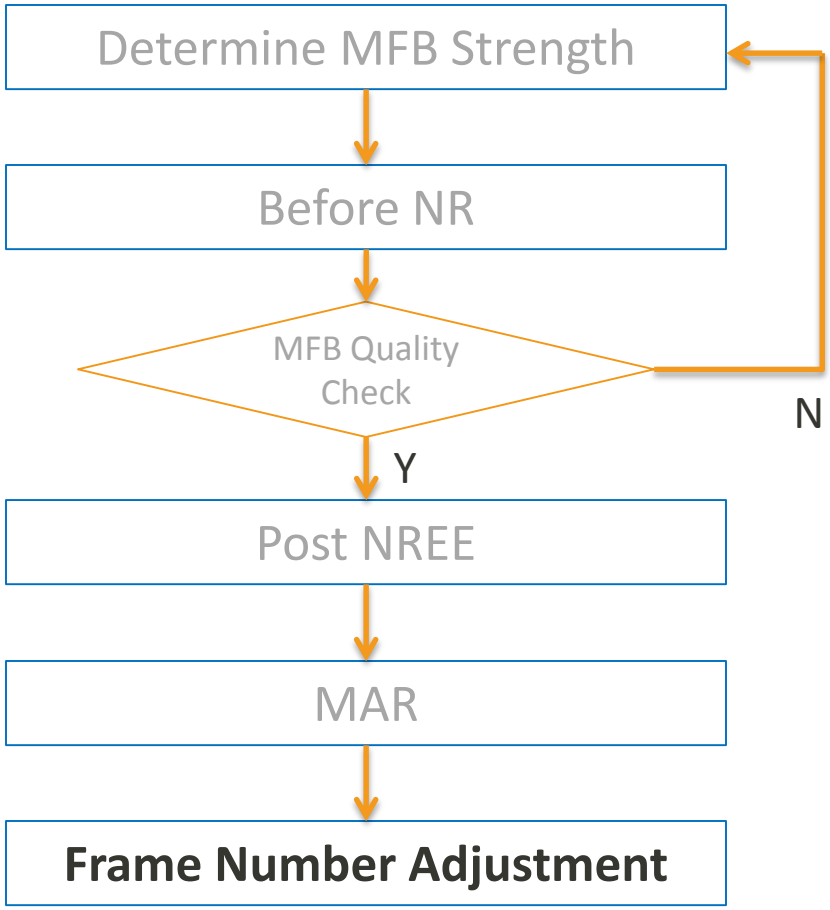


MAR – Result

img_afbld_out__4032x3016_8d_s1.bmp

MFNR_A.bmp

MFNR Tuning Guide



ISO Adaptive Frame Number

- InMFNR v2.0, It's available to change frame number by shooting ISO
  - The more frame number, the better SNR of image
  - Low ISO: original noise is low, use less frame for shooting performance
  - High ISO: Gradually increase frame number for image quality

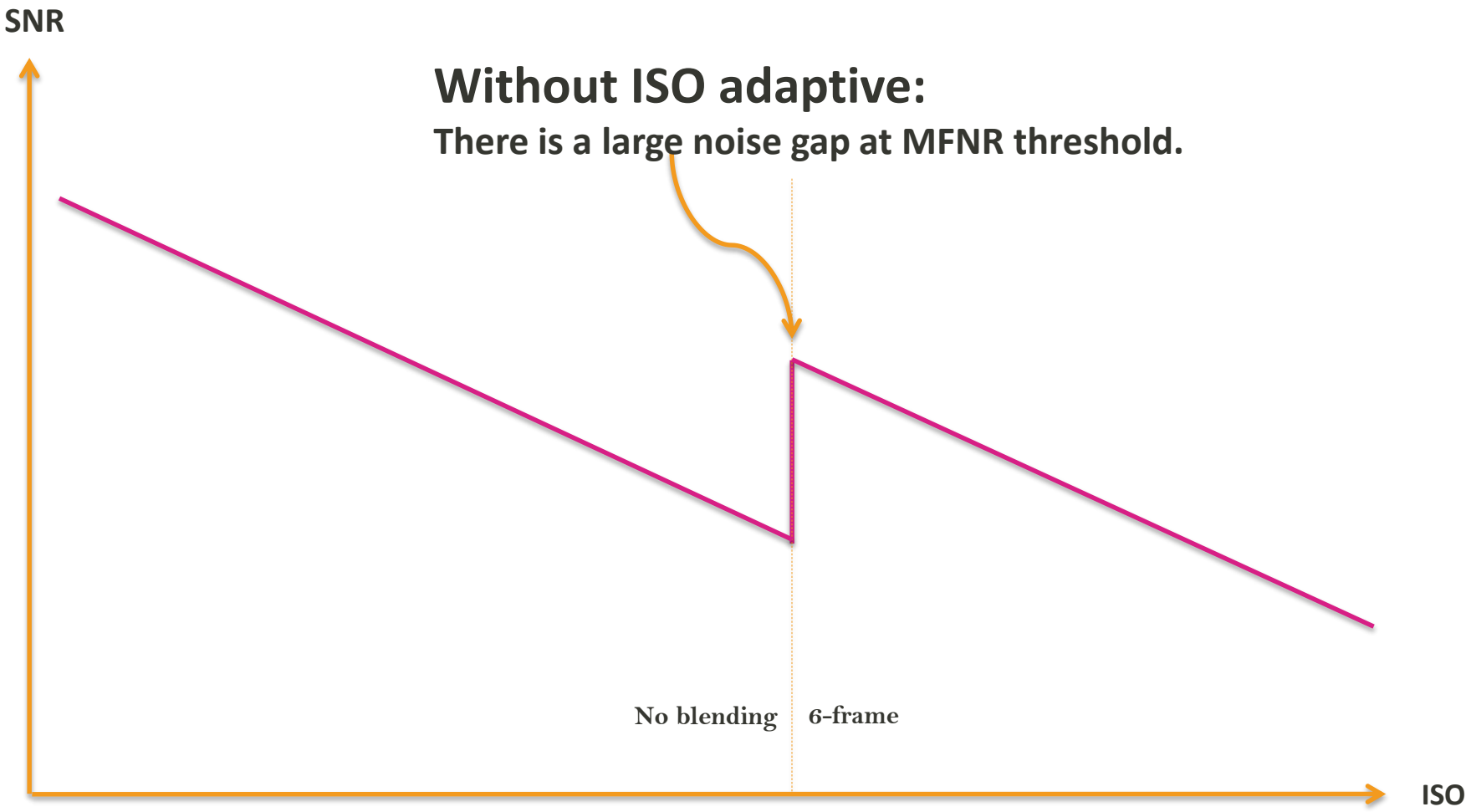
Comparison of different frame number MFNR result:

No blending

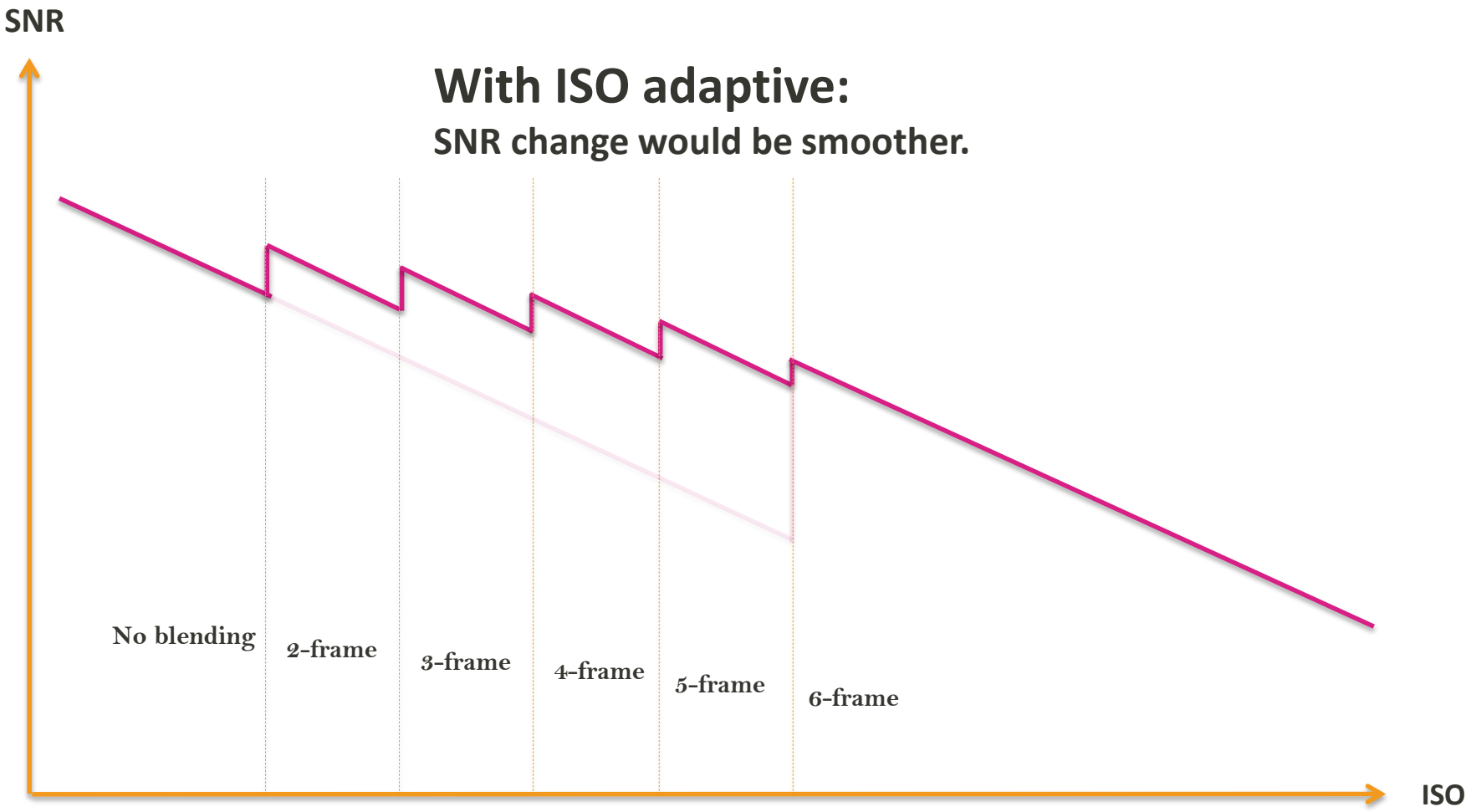
2-frame MFNR

6-frame MFNR

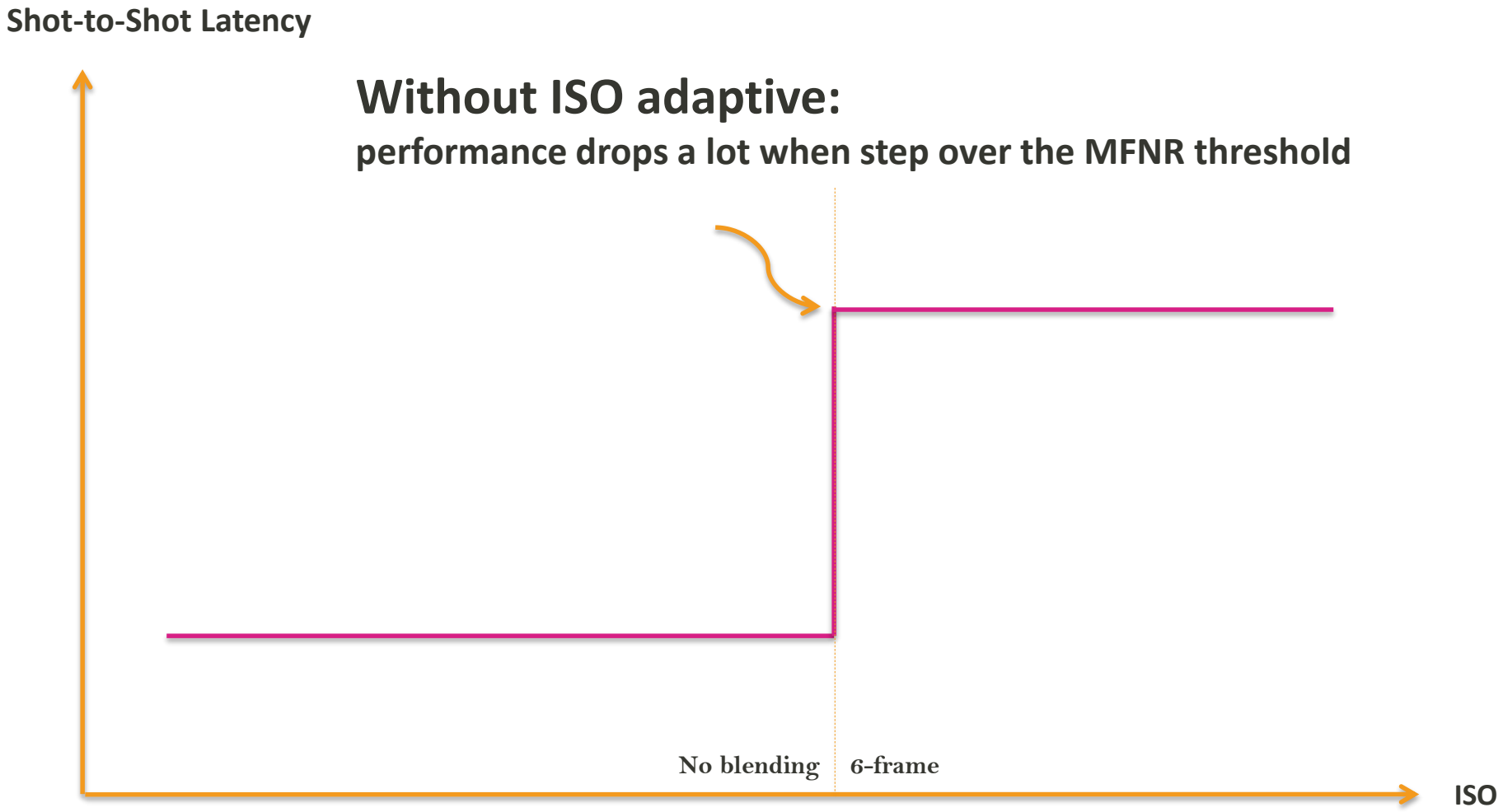
ISO Adaptive Frame Number – Image Quality



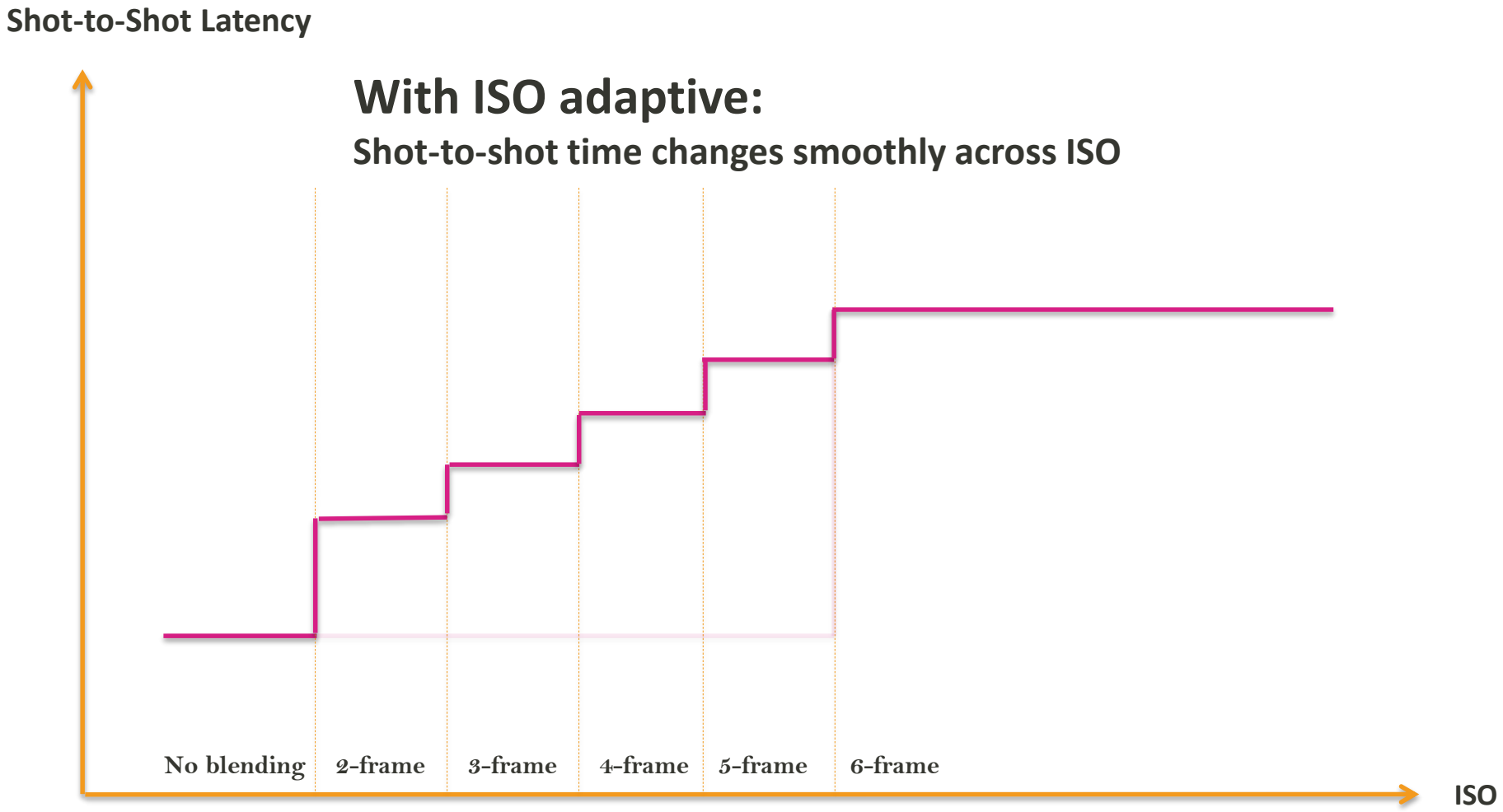
ISO Adaptive Frame Number – Image Quality



ISO Adaptive Frame Number – Performance

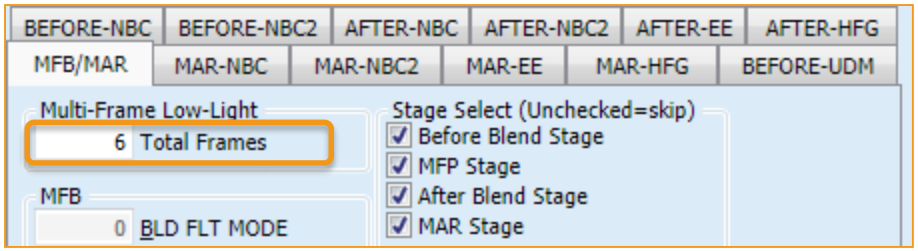


ISO Adaptive Frame Number – Performance



ISO Adaptive Frame Number – Simulation

- Set “Total Frame” value in tool for simulation



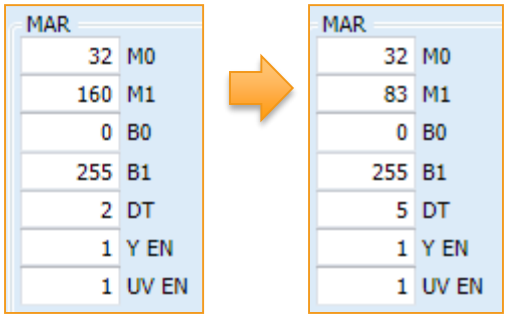
ISO Adaptive Frame Number – Tuning

- Initially MFNR should be tuned with the highest frame number.
- Once frame number falls, **AFTER-NBC** and **MAR_M1** need to be revised to keep the noise level consistency

- MAR_M1:

New_M1= M0 + (Old_M1-M0)x(New_FrameNum-1)/(Old_FrameNum-1)

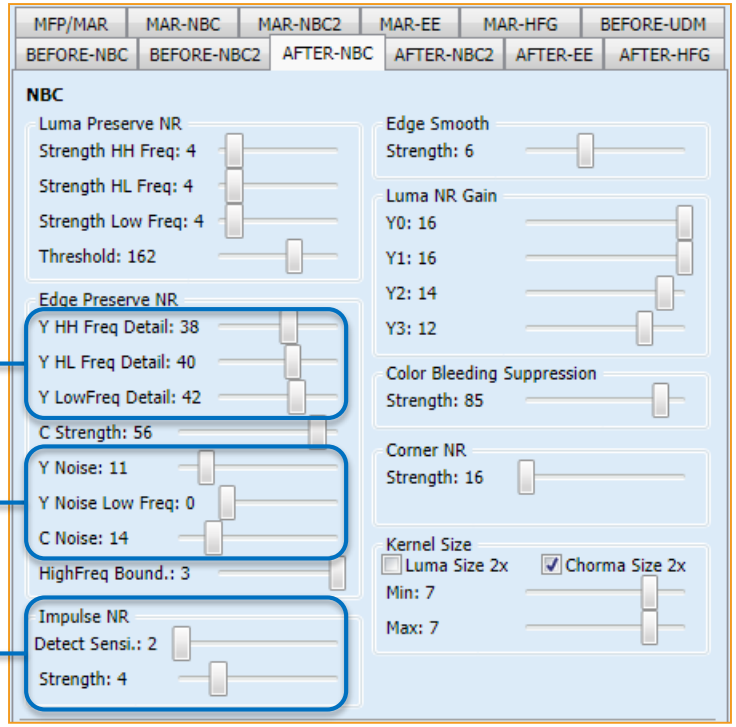
Ex: 6-frames down to 3-frames:
New_M1 = 32 + (160-32)x(3-1)/(6-1) = 83



ISO Adaptive Frame Number – Tuning (AFTER-NBC1)

Y/C Noise : NewValue ≈ OldValue x (OldFrameNum/NewFrameNum)^0.5

Y HH/HL/L Detail : NewValue ≈ OldValue / (OldFrameNum/NewFrameNum)^(0.25~0.4)



FrameNum ↓ **Impulse NR**↑

EX: AFTER-NBC in **6-frame** MFNR:

Y HH Detail = 45

Y Noise= 8

Down to **3-frame** MFNR:

Y HH Detail = 45 / (6/3)^0.25 = 38

Y Noise = 8 x (6/3)^0.5 = 11

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