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DSC Image Processing Pipeline

NOVATEK Microelectronics Corp.

IM

Confidential NT96432/96200 Block Diagram

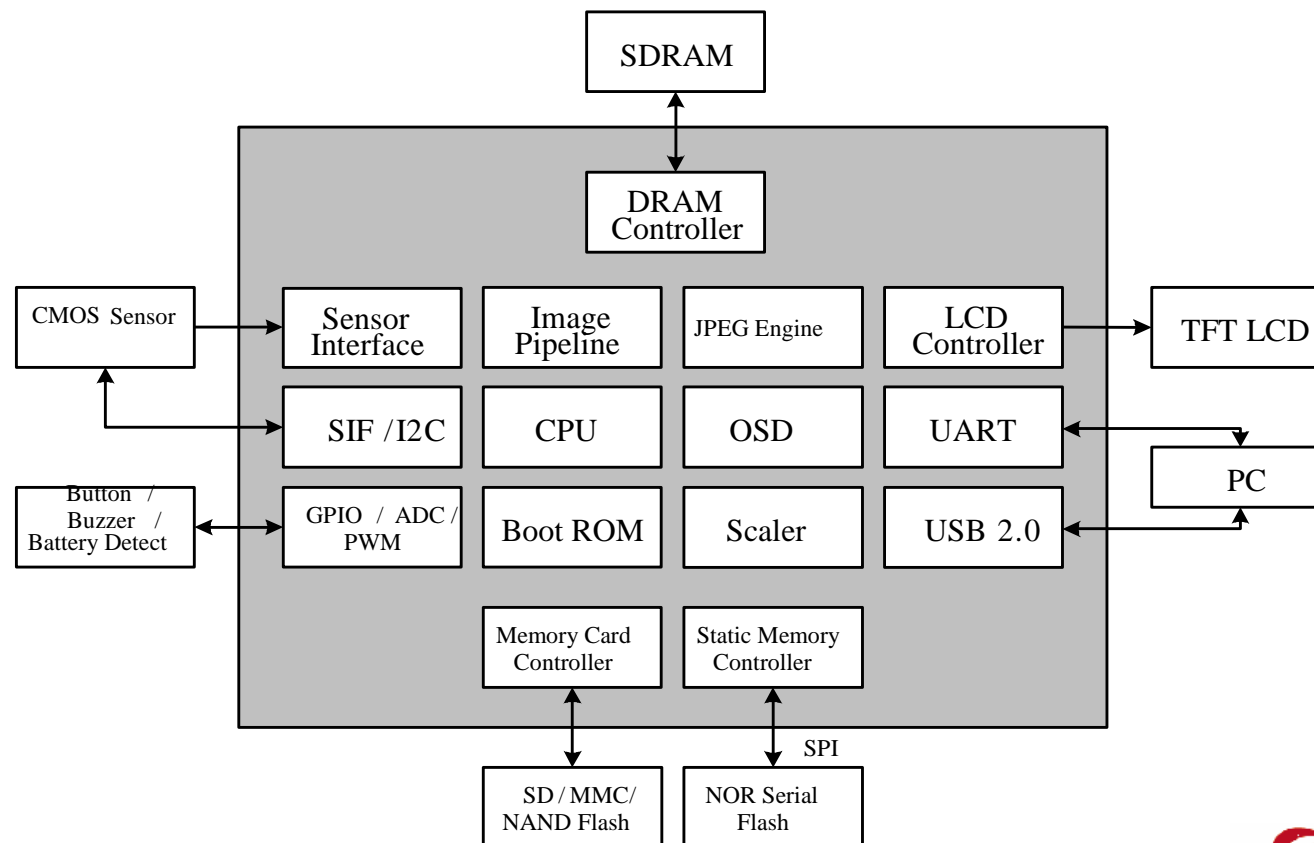
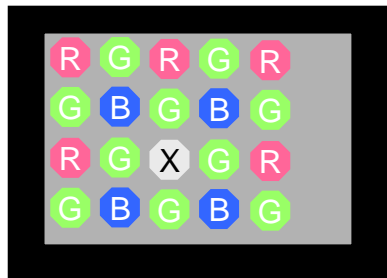


Image Processing Inside DSC Controller

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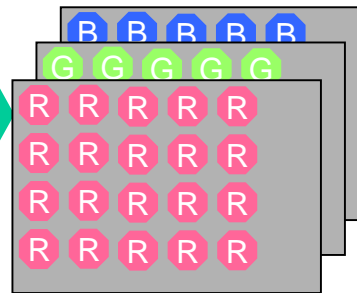
What's we have from
image sensor



Only one color component
per pixel position

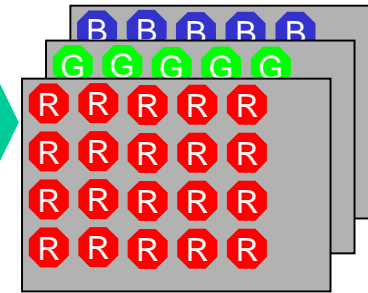
Color
interpolation

Now, we have three colors
for each pixel

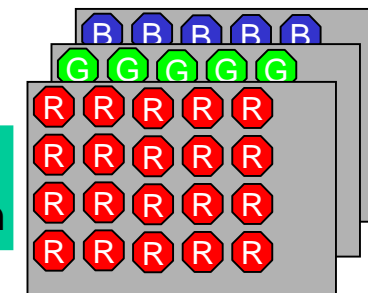


Color
correction

Right color is reproduced,
but image is still blur

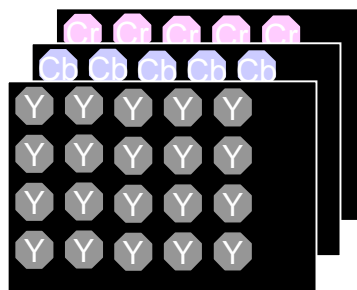


Edge
enhancement



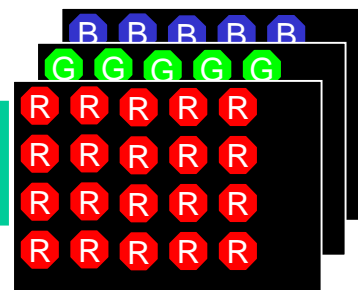
Edge sharpening is used
to recover edge strength

What's we feed to
image compression



Compression needs YCbCr
image input

Color
transform



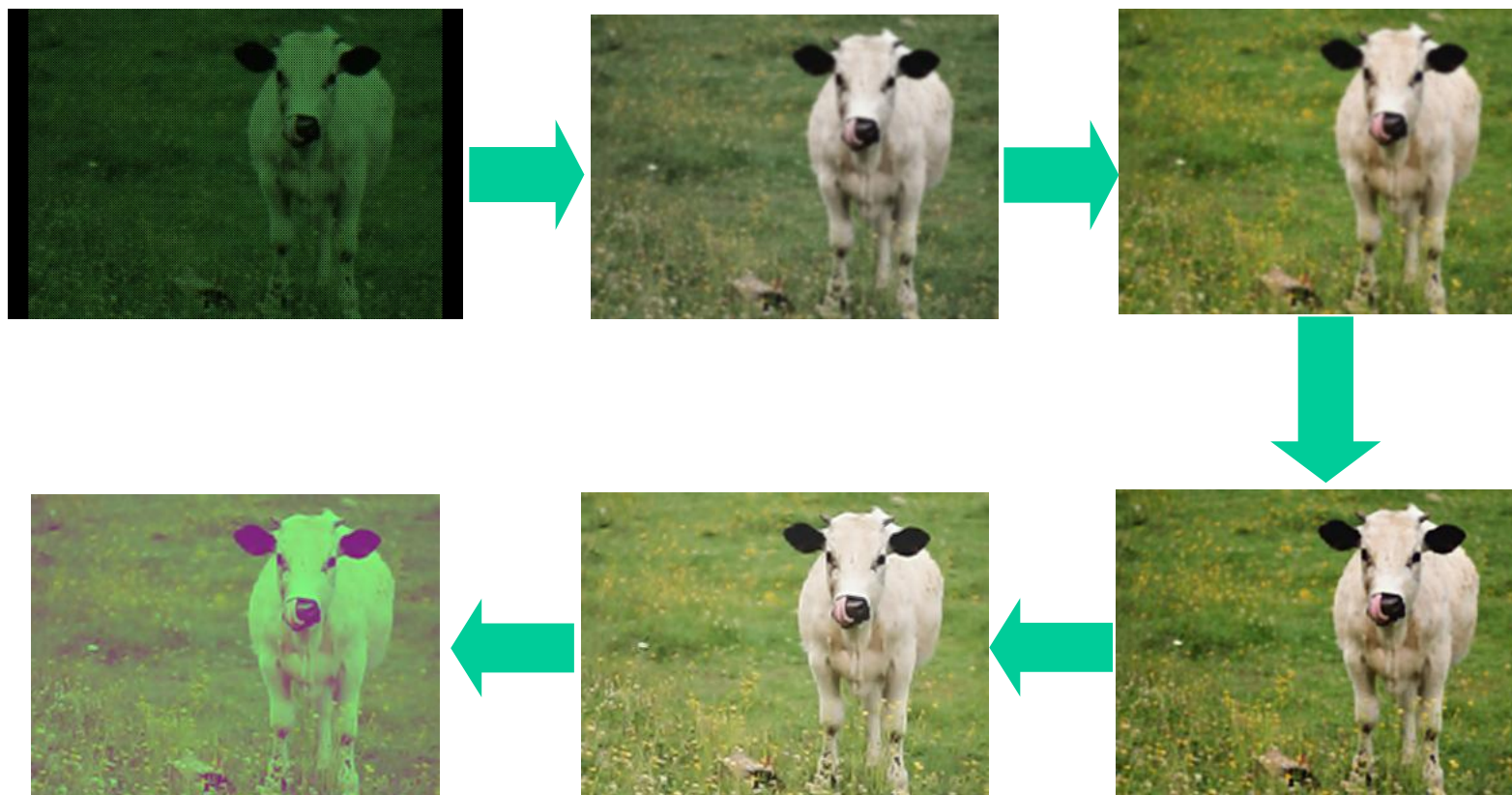
To fit human perception &
display characteristics

Gamma
correction

Edge sharpening is used
to recover edge strength

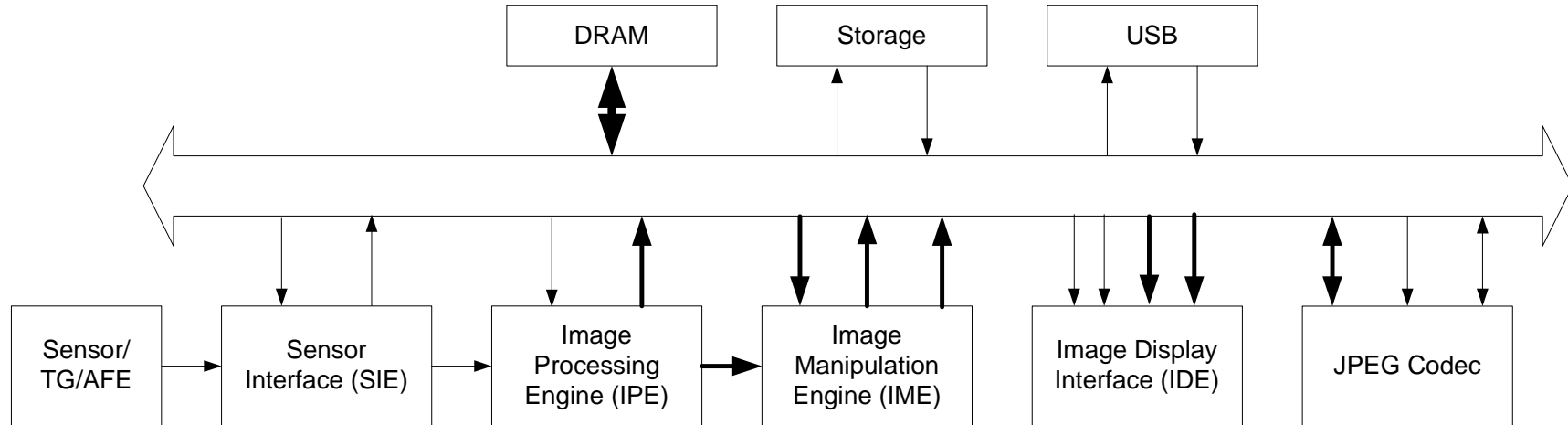
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Image Processing Samples



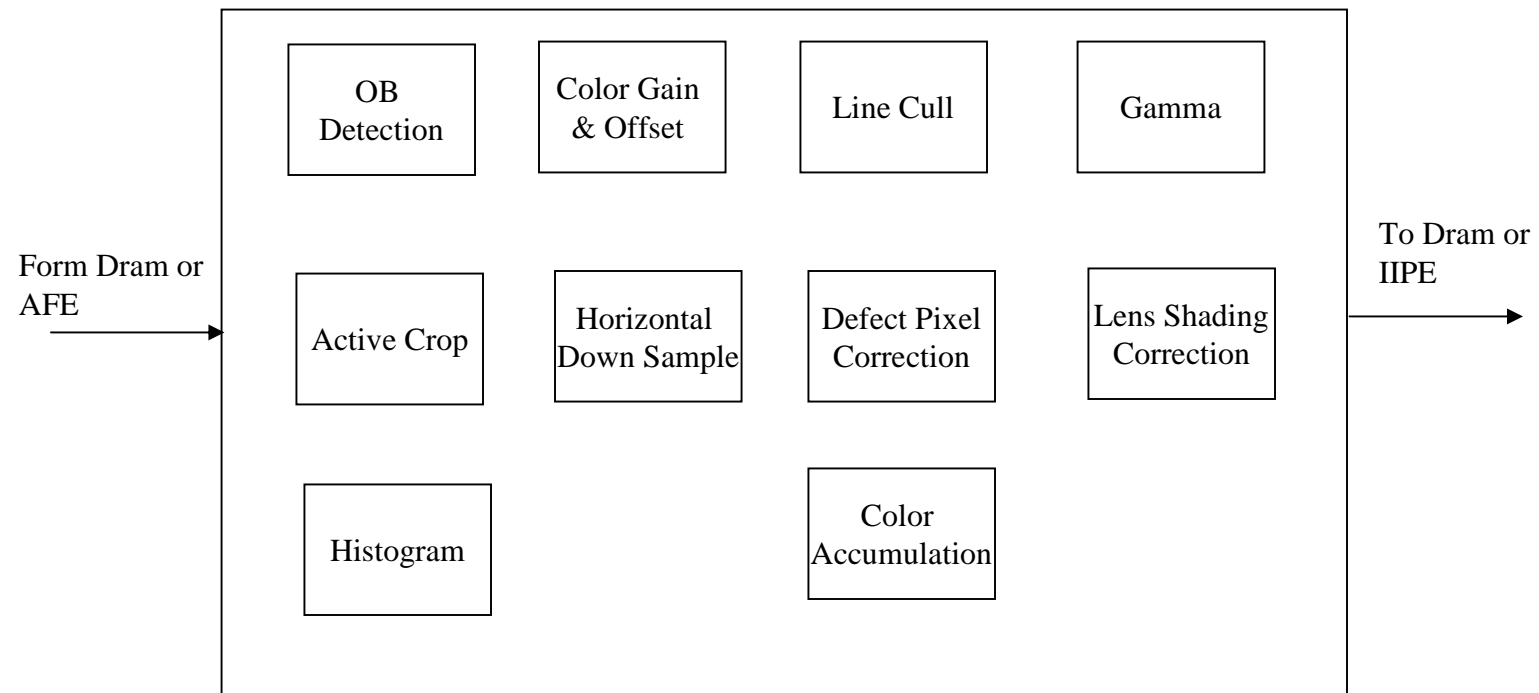
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Image Pipeline



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Sensor Interface Engine (SIE)



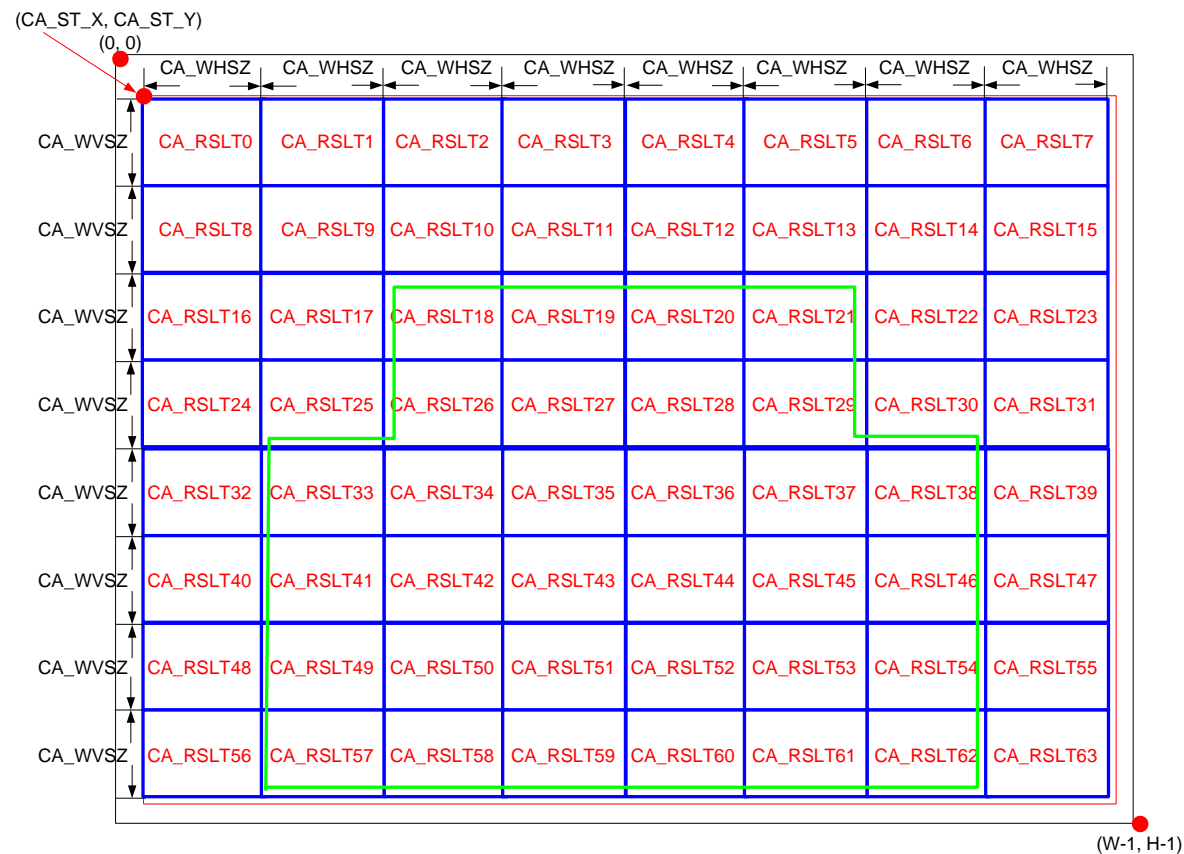
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SIE Feature List

- **Optical Black Detection & Black Level Clamping**
 - ✓ Remove sensor dark current accumulation
- **Lens Shading Compensation**
- **Blemish Concealment**
- **Line Cull**
 - ✓ Raw image vertical subsampling
- **Raw Image SubSampling**
 - ✓ Raw image horizontal subsampling
- **Color Offset & Gain**
 - ✓ AWB color gain
- **Gamma LUT 1**
- **Color Accumulation**
 - ✓ AE & AWB analysis
- **Histogram Accumulation**
 - ✓ Instant color or luminance distribution

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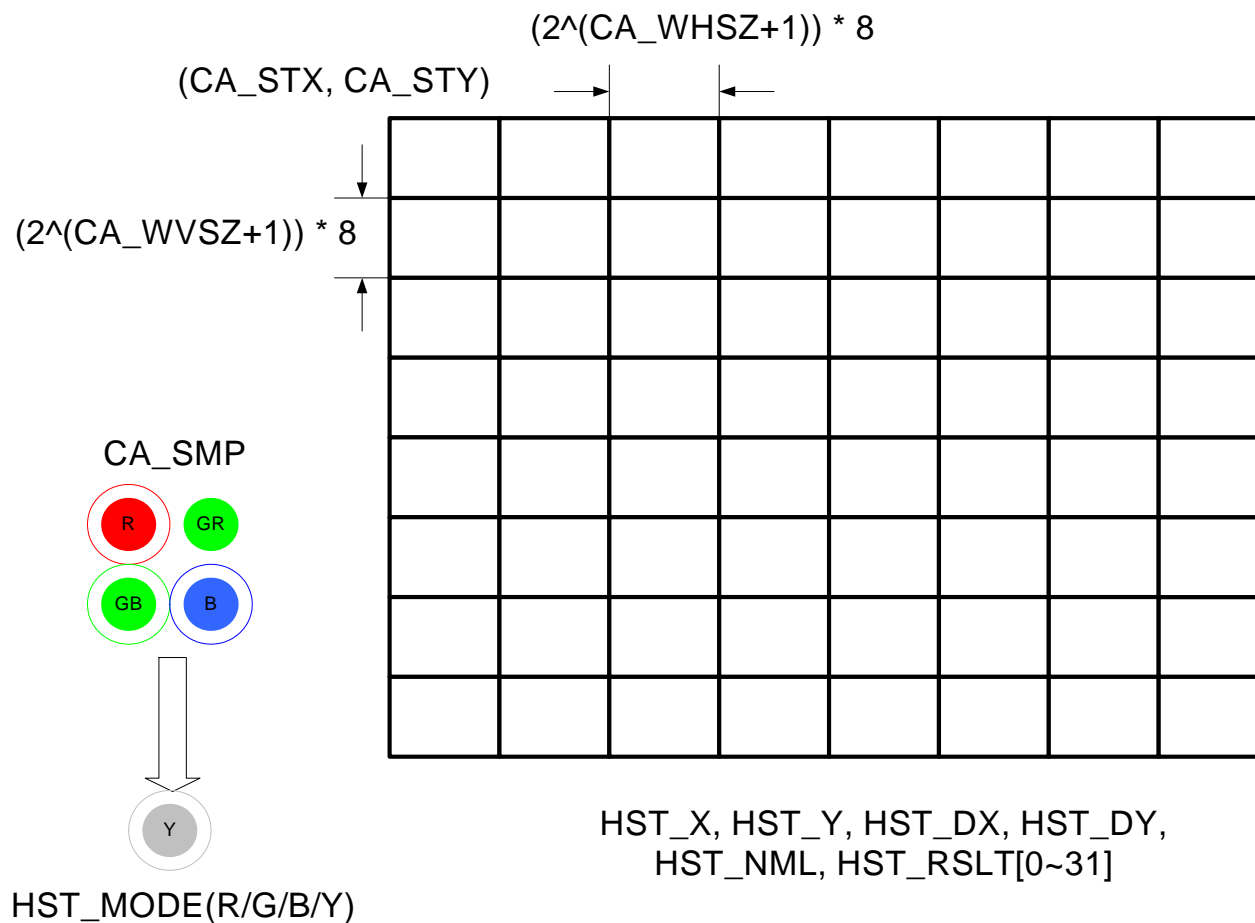
Color Accumulation



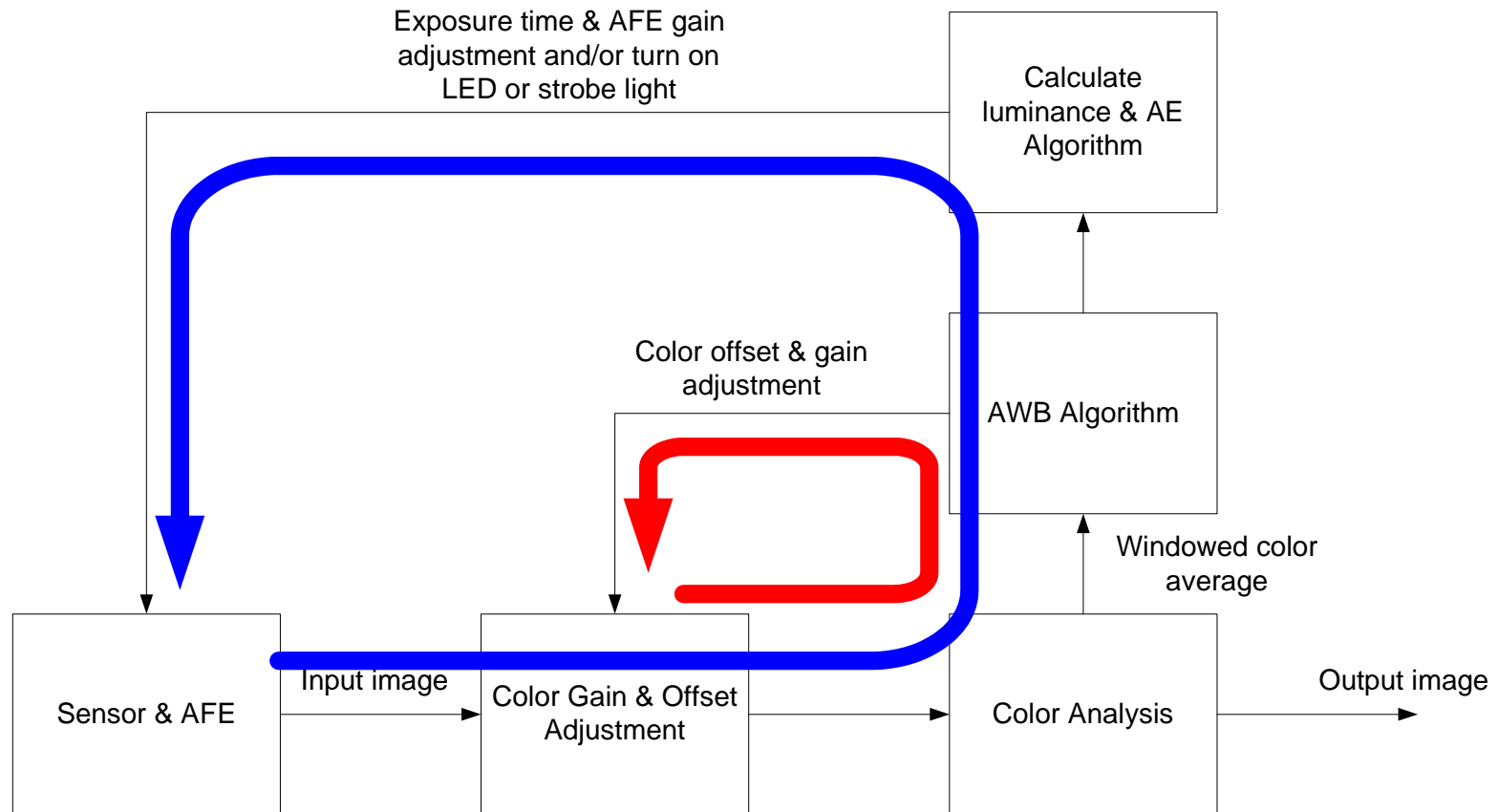
- NT96431 supports $8 \times 8 = 64$ color accumulation windows to facilitate AE and AWB analysis
- Programmable starting point and window size

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Histogram Accumulation

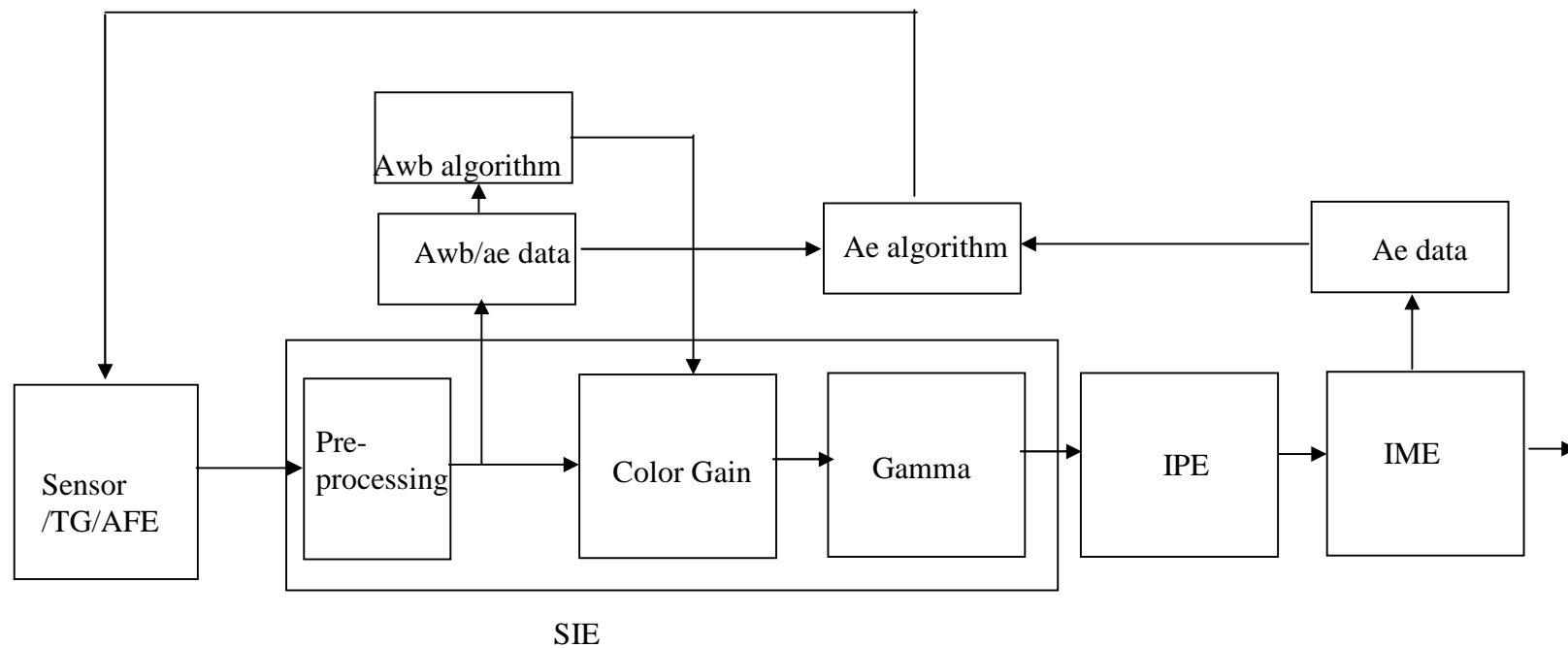


32 bins histogram assists AE and image distribution display on the fly



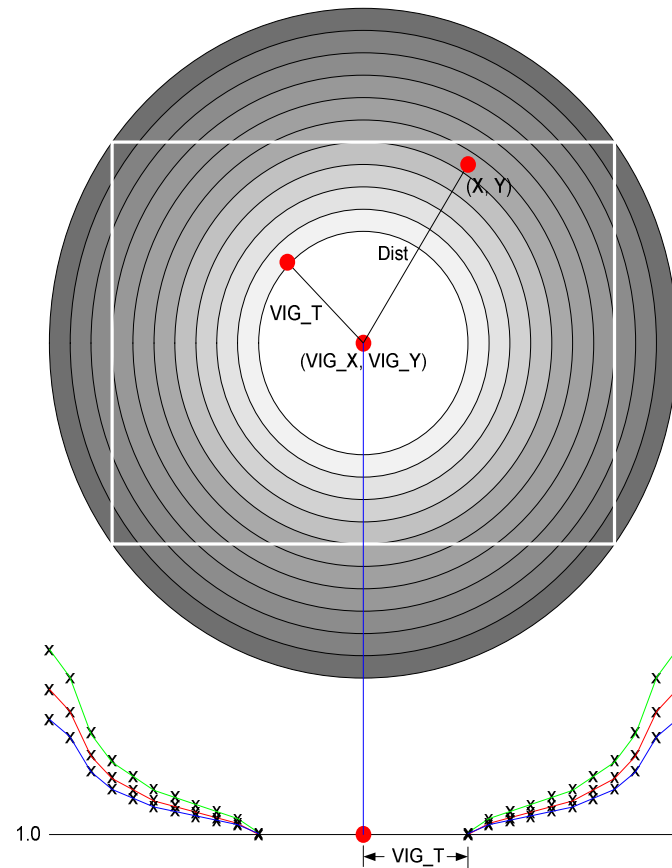
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AE/AWB Flow



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Lens Shading Compensation



Programmable lens shading profile, can fit any convex lens shading defect

Confidential Color Shading Correction: 2 Approaches

NT96432 Provides 2 HW Approaches for Color Shading Correction!!

1. Circular & Linear Color Shading Compensation

- Embedded in image pipeline
- No penalty for shot-to-shot time
- Useful for regular color shading

2. Blockwise Color Shading Correction

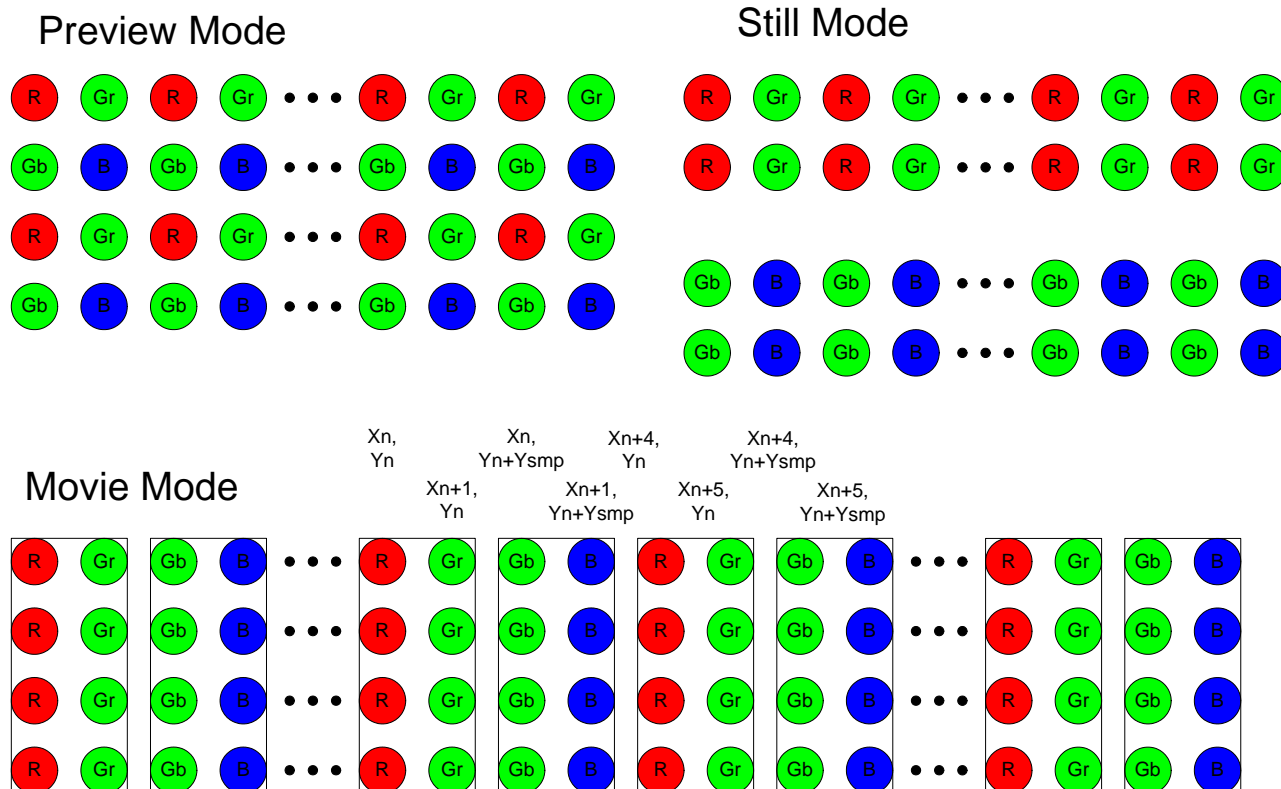
- Need mask picture
- Slight delay for shot-to-shot time
- Only support still capture
- Useful for irregular color shading

Confidential Three Remedies for Defect Pixels

DSP provides three remedies for defect pixel concealment

1. **SIE direct defect pixel concealment (HW)**
 - Need pixel address from DRAM
 - Embedded in pipeline
2. **Noise reduction (HW)**
 - Tunable edge sensitive 2D median filter
 - Embedded in pipeline
3. **Software defect pixel concealment**
 - 20us/pixel, for still image defect pixel
 - Need pixel address stored in DRAM

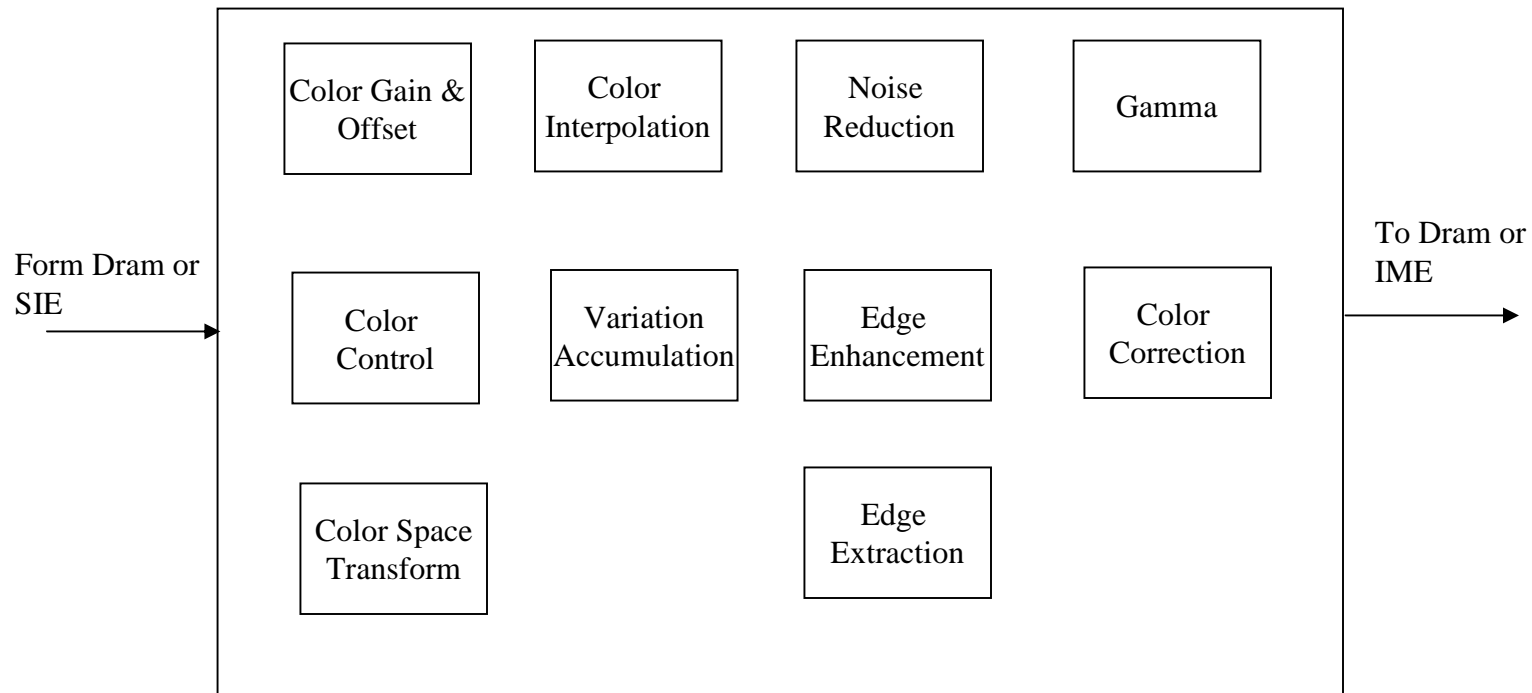
Confidential CCD Input Format at Different Mode



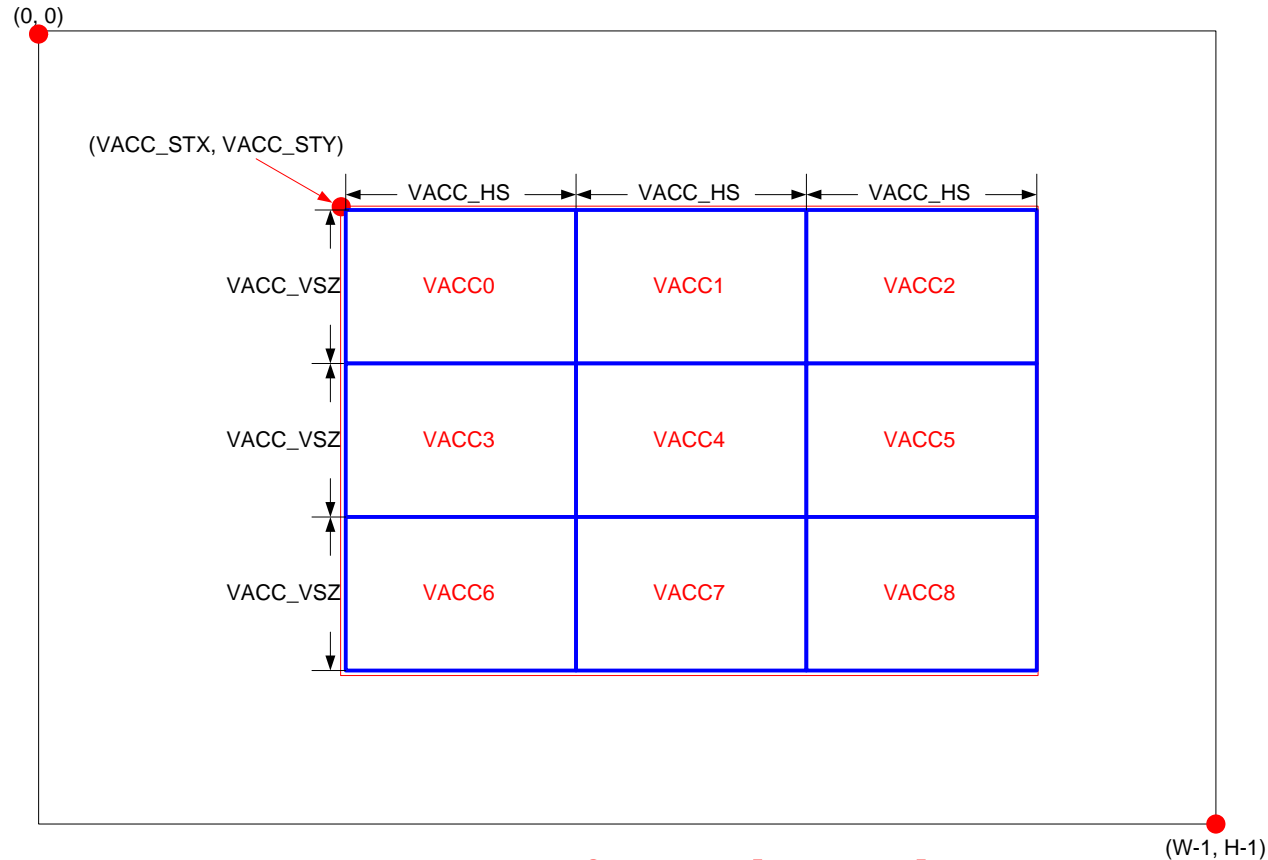
NT96432 supports Sony & Sharp movie CCD
Panasonic movie CCD will be supported in our next chip

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Image Processing Engine



Confidential AF Windows (Variation Accumulation)



- NT96431 supports $3 \times 3 = 9$ focusing windows to facilitate AF analysis
- Programmable starting point and window size

Noise Reduction

- **Edge sensitive 2D filtering**
- **Programmable filtering control**
- **Usable for preview, still capture & video clip**
- **Capable of canceling spot noise under low light condition**

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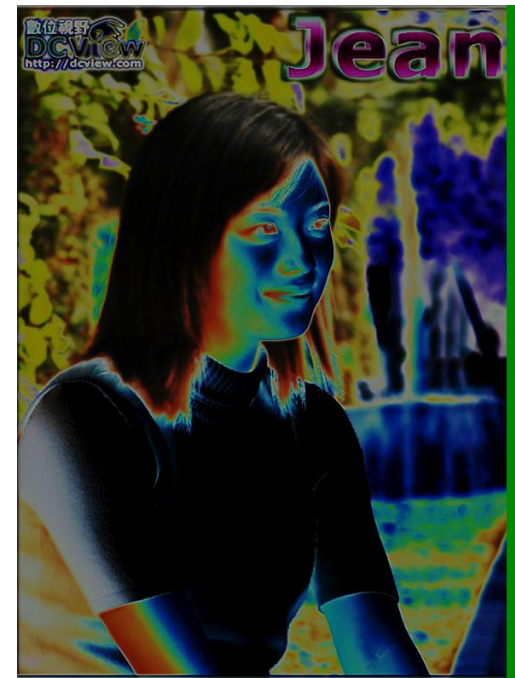
Color Effect



Negative



Sepia



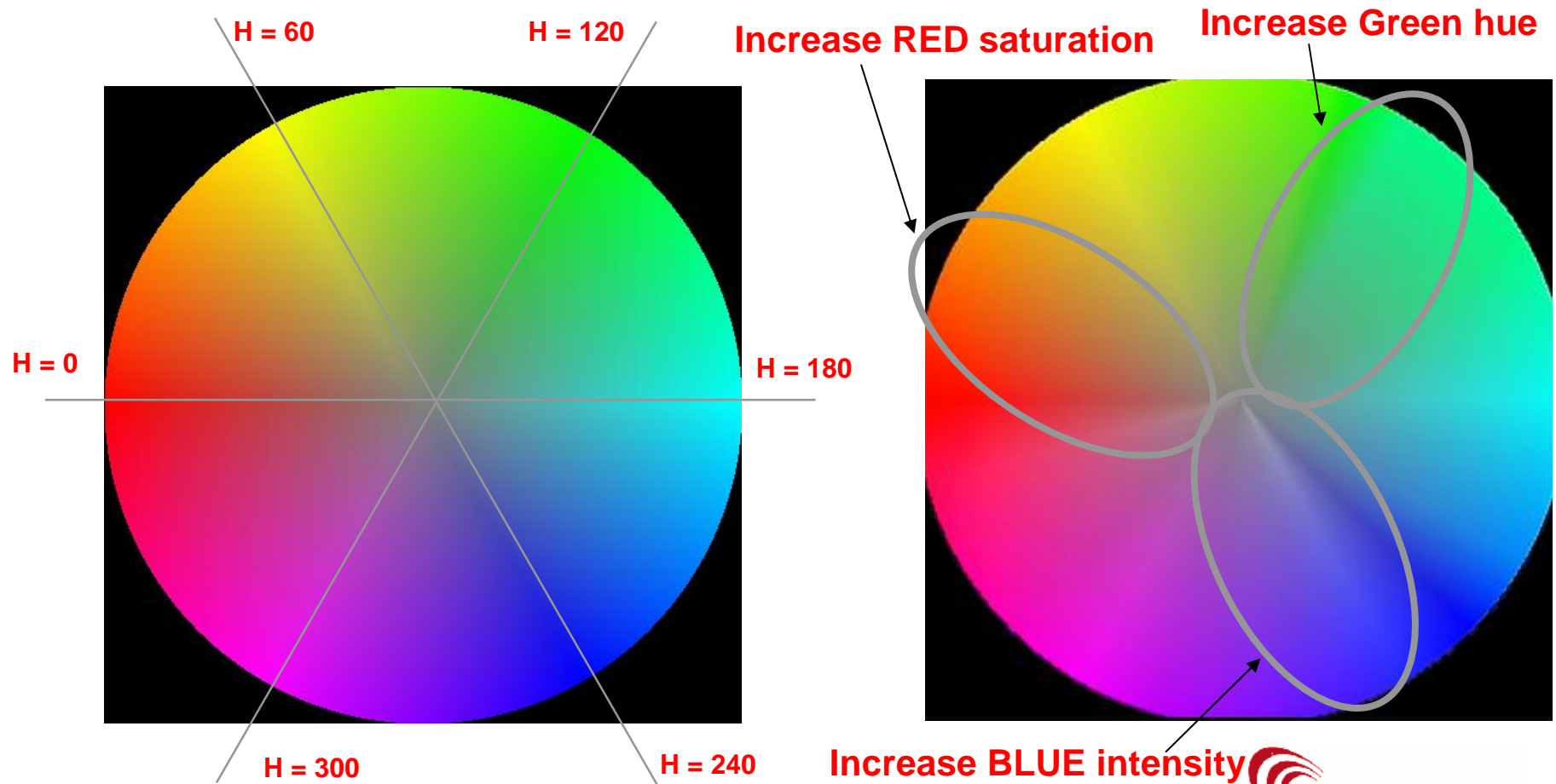
Solarize



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Proprietary Color Control Technology

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Color Control Image Samples



Original



Green tone

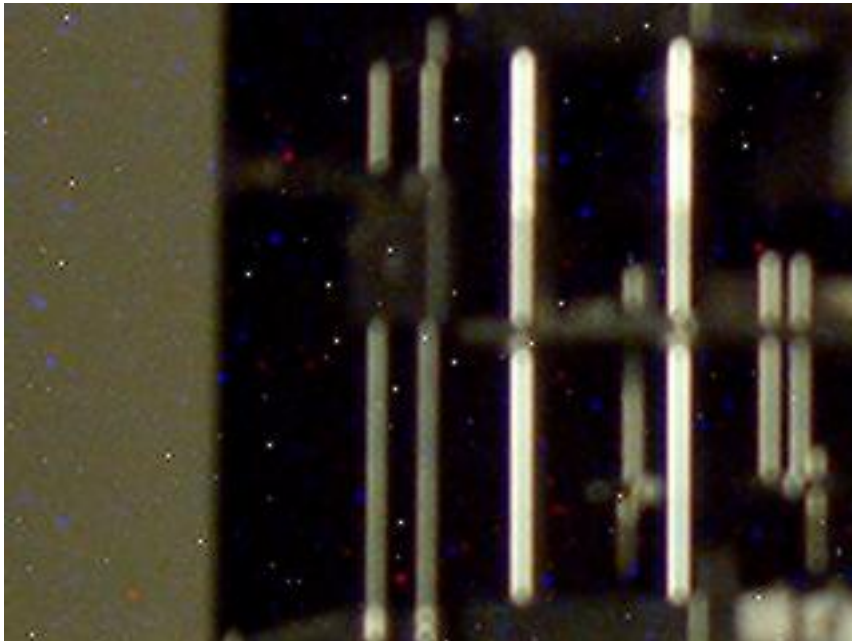


Skin tone enhanced

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DFS Image Comparison

Exposure time = 8 sec



DSP DFS OFF



DSP DFS ON

DSP DFS removes FPN and spot noise!

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Nonlinear False Color Reduction(1)

- There are nonlinear false color in high light area, it is very bad when it occurs in our skin. We can reduce it, and get a satisfied image.

0%



50%



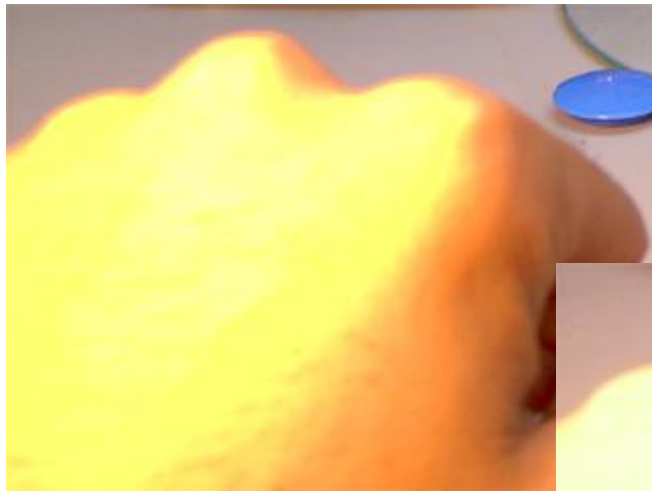
100%



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Nonlinear False Color Reduction (2)

- Improve the tone response of each color channel, and get great detail.



0%



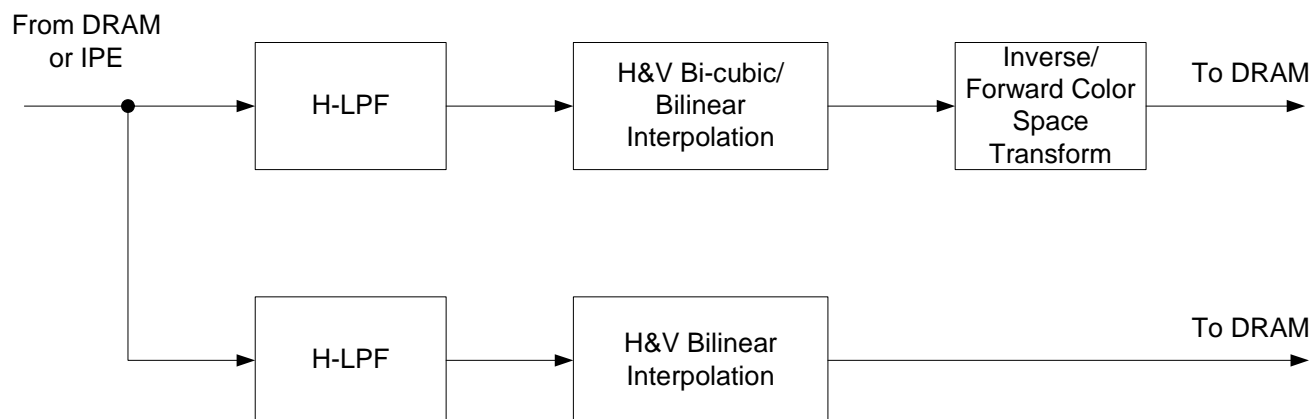
50%



100%

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Confidential Image Manipulation Engine (IME)



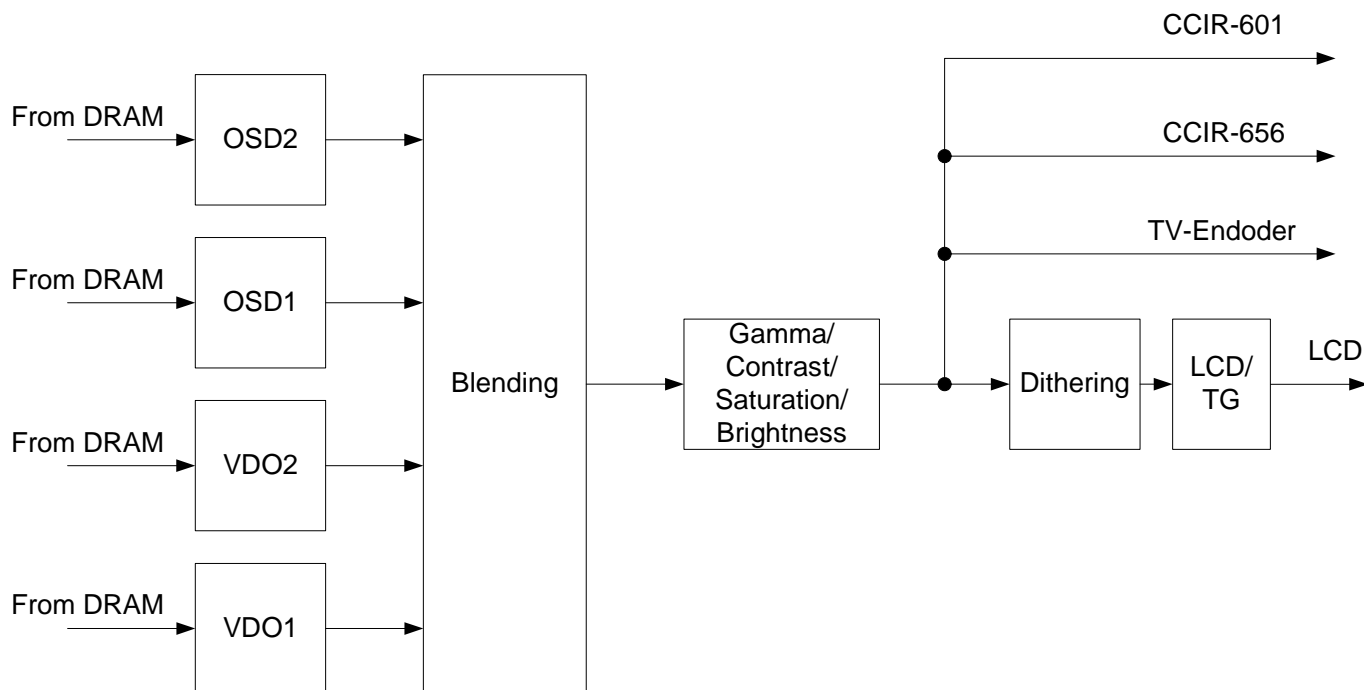
- Dual scaler outputs for single input image
- Y channel can be bicubic interpolation
- A forward/inverse color space transform is designed for $RGB \leftrightarrow YCbCr$ transform
- Input and output ping pong buffering mechanism

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Image Processing Flow

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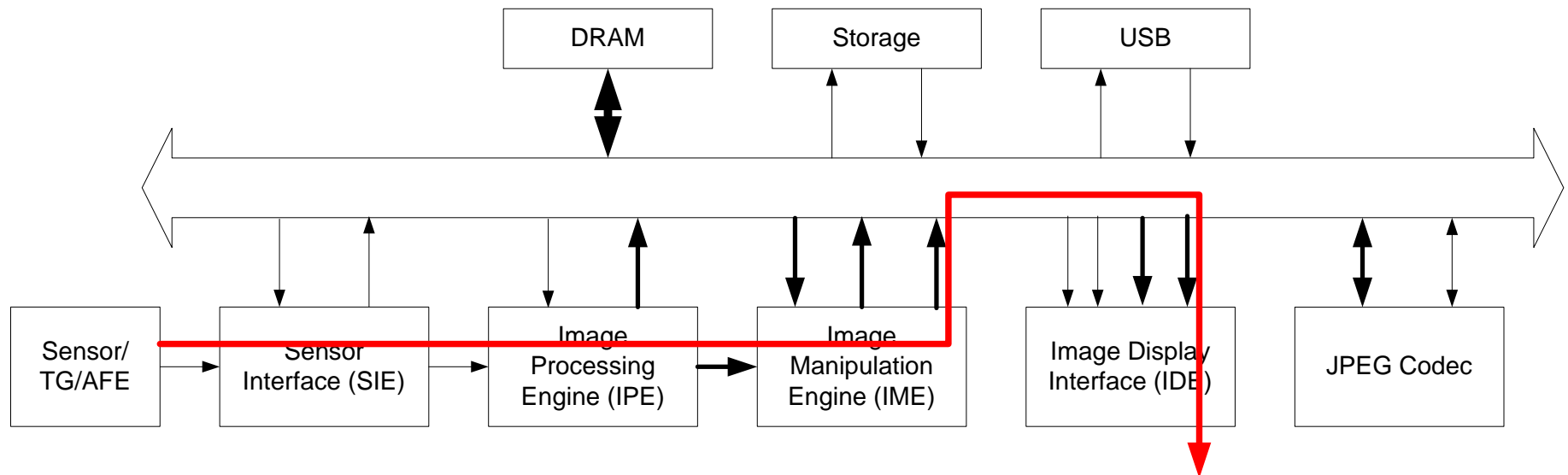
Image Display Engine (IDE)



- 2 video & 2 OSD buffers to support various display needs
- Support picture-in-picture
- Support dithering for low bit-depth LCD panel

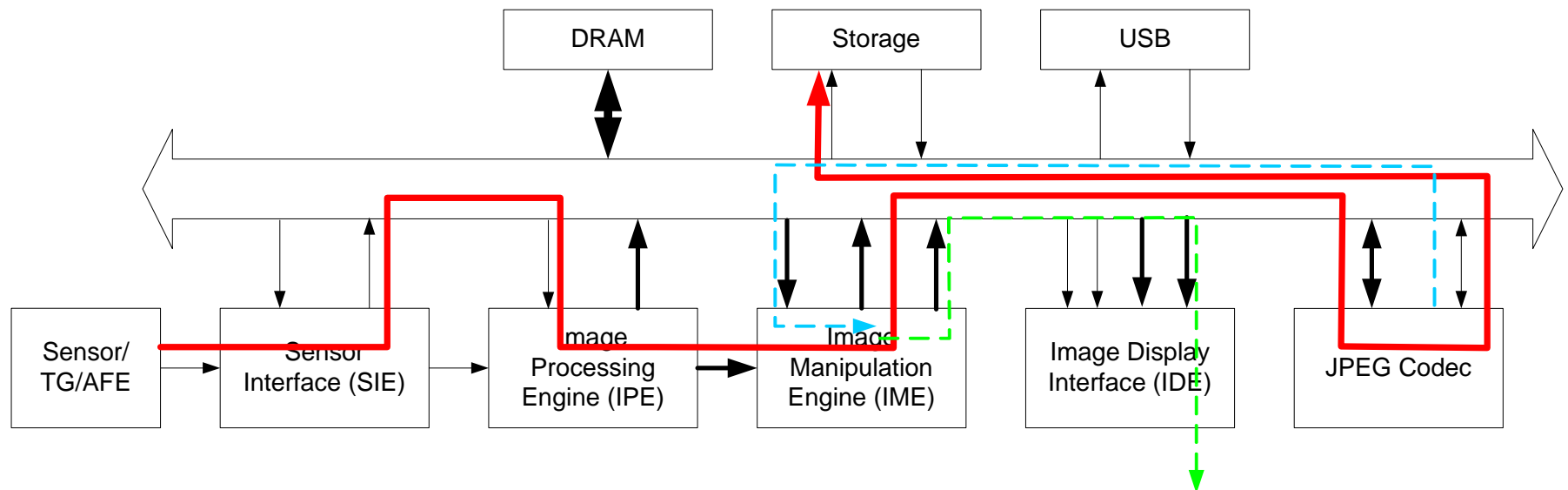
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Preview



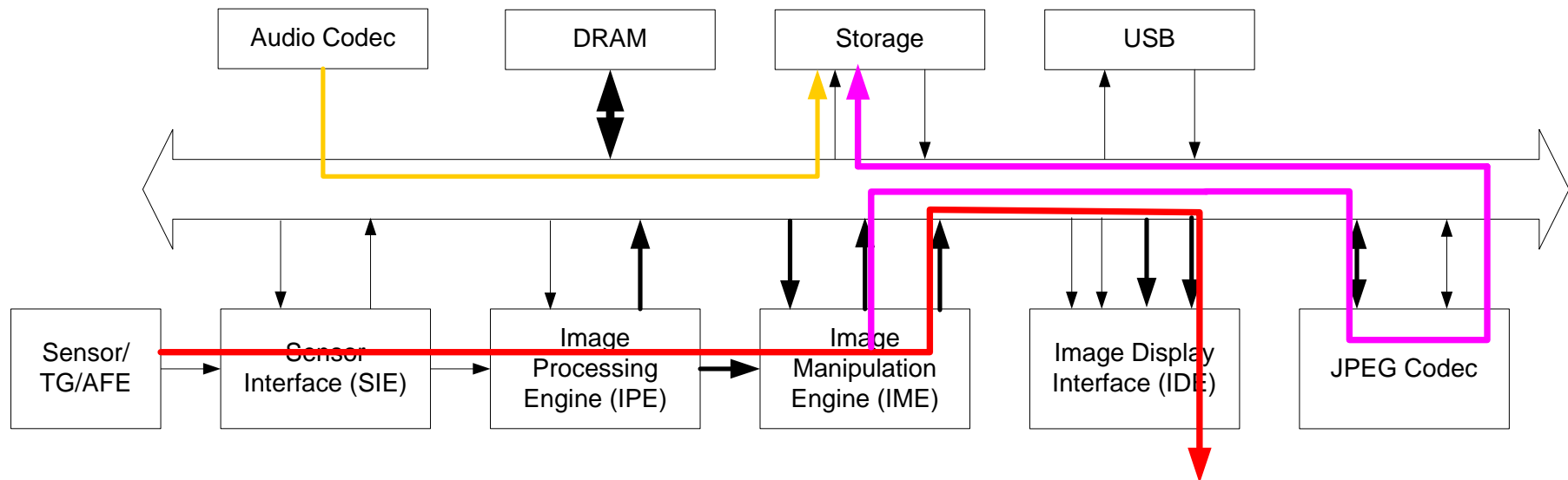
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Still Capture



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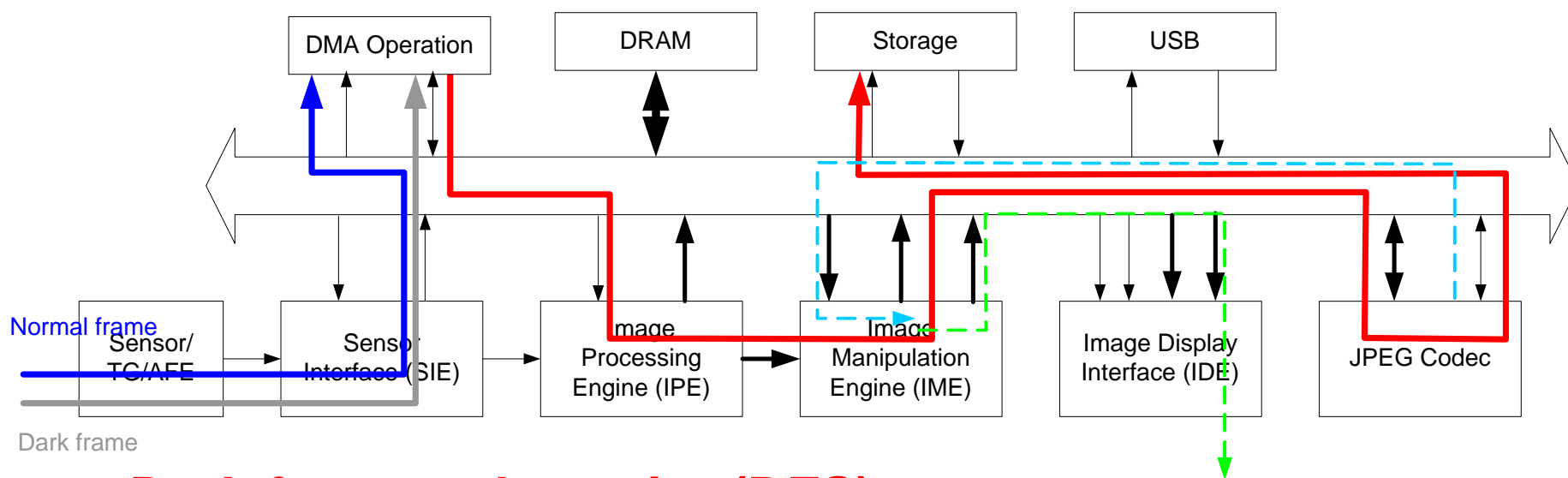
Video Recording



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Dark Frame Subtraction

DSP supports HW dark frame subtraction!



- **Dark frame subtraction(DFS) can remove sensor fixed pattern noise**
- **DFS can not remove noise completely without further accompanied processing**