CONFIDENTIAL B

P40 DMEE
Introduction & Usage

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Outline

- **DM Improvement**
  - DM-P1 Upgrade
  - DM-P1&DM-P2 Blending
  - Pos/Neg EE Response
  - Clipping Recovery
- **EE Improvement**
  - HP smoothing
  - YCE/CCE
  - Slow transition
  - Chroma Boost
  - Coring by Band
  - Pos/Neg Gain
  - PBC

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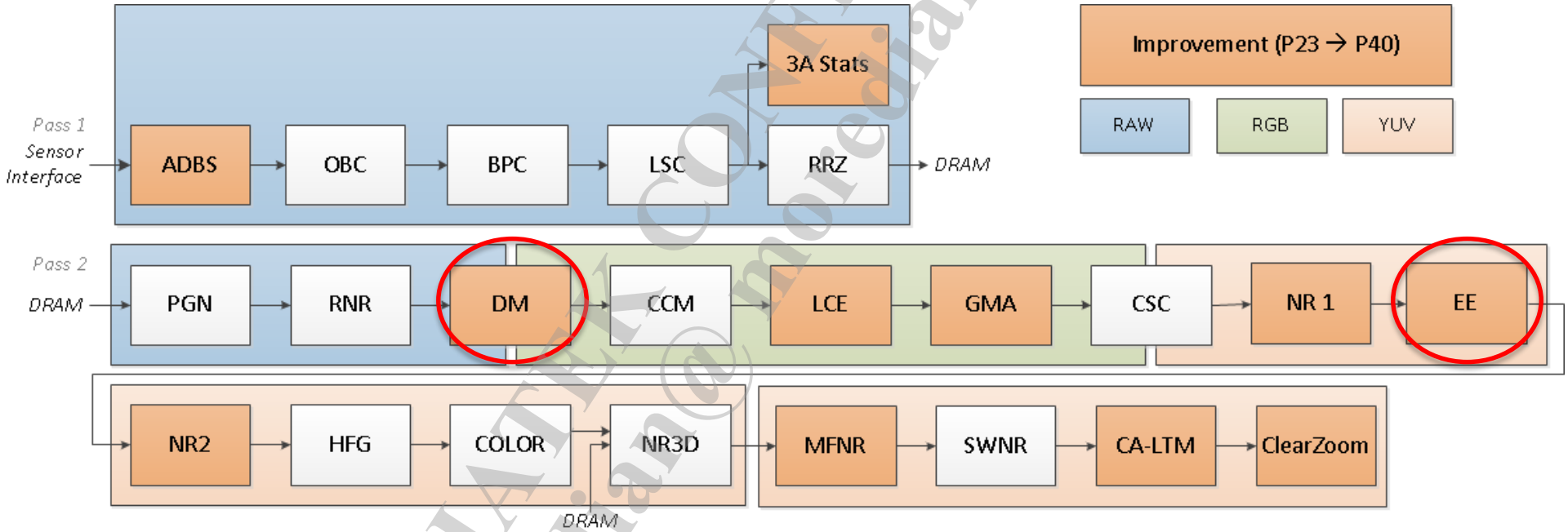
P40 Block Diagram



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Outline

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  - DM-P1 Upgrade
  - DM-P1&DM-P2 Blending
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  - YCE/CCE
  - Slow transition
  - Chroma Boost
  - Coring by Band
  - Pos/Neg Gain
  - PBC

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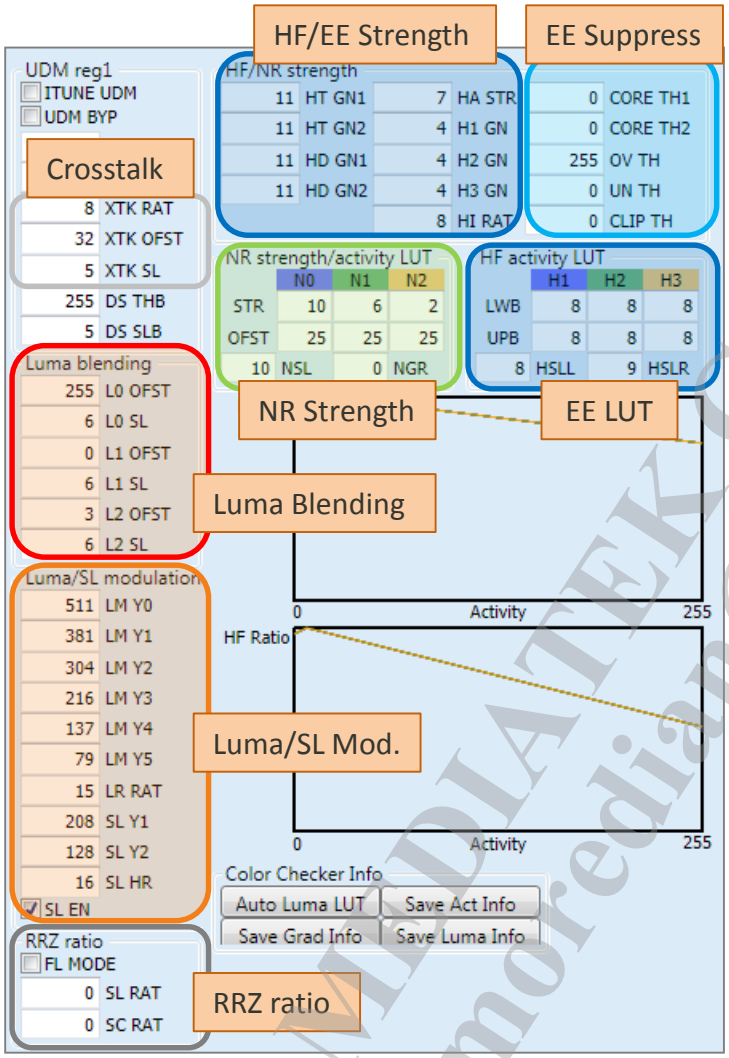
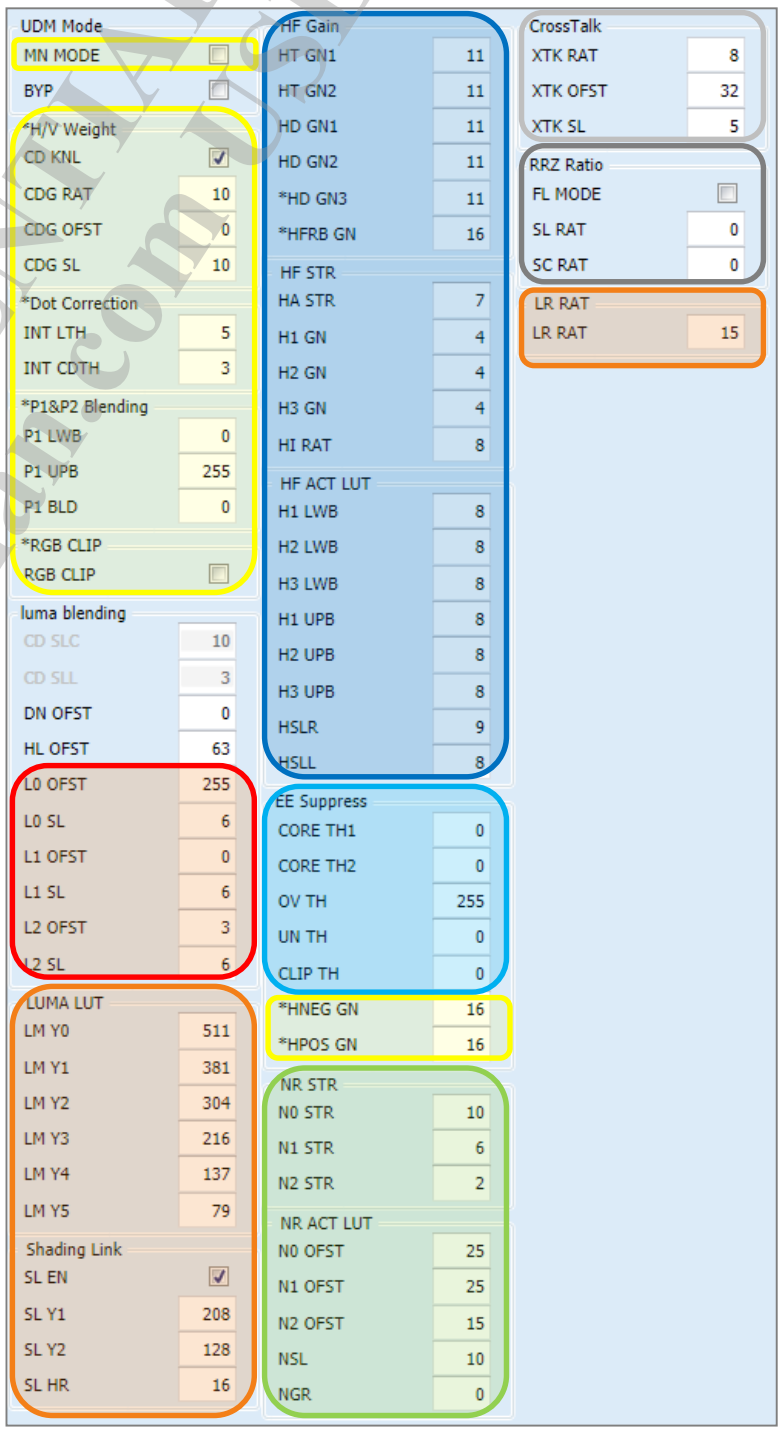
P23 DM → P40 DM





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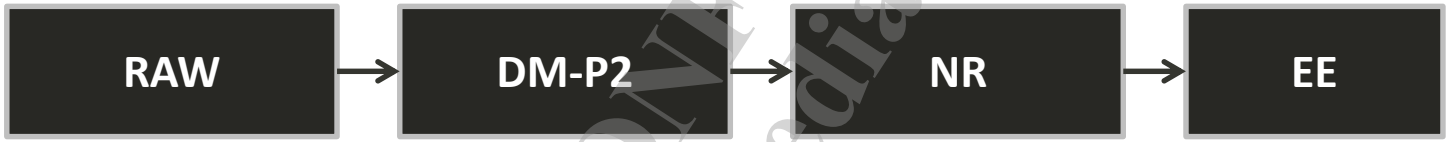
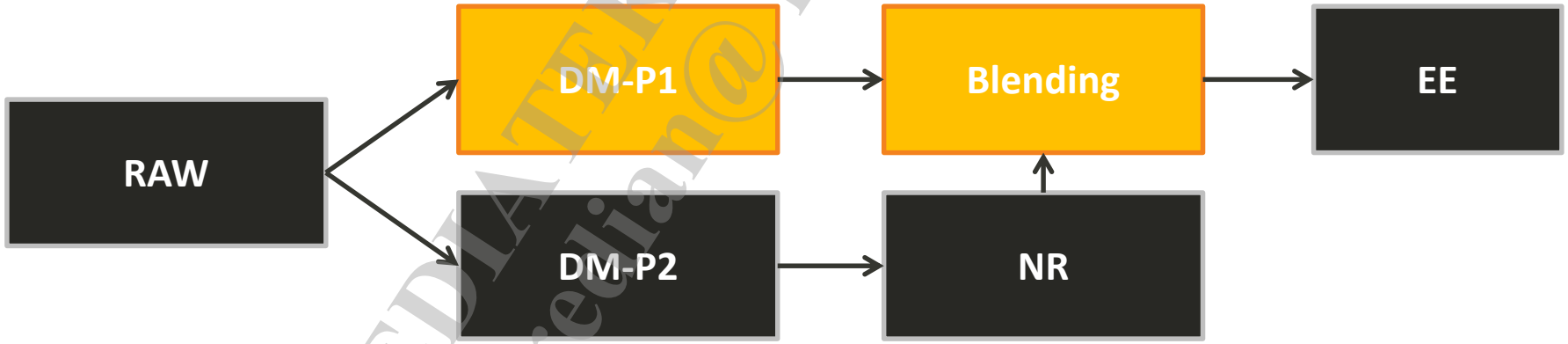
DM Flow Change

P23



P40



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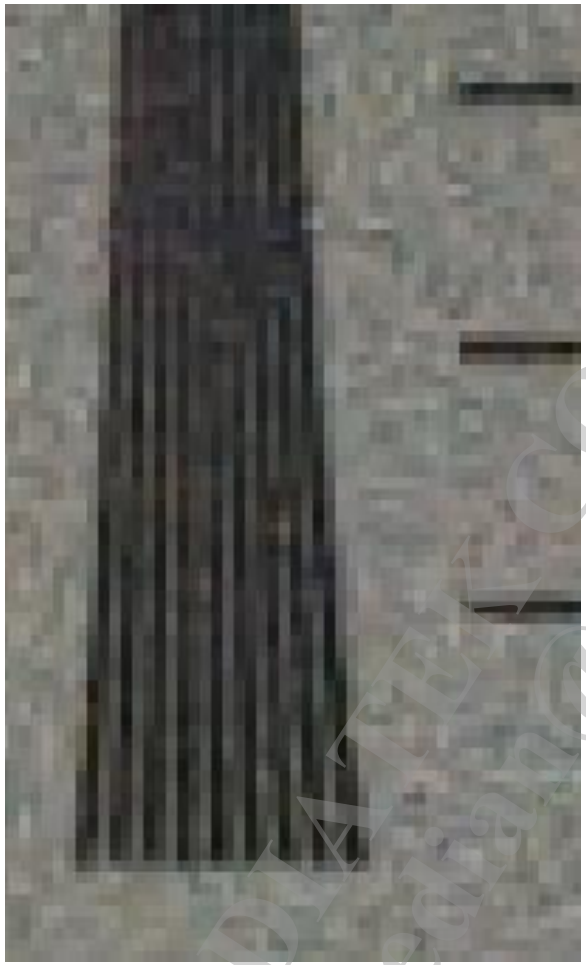
DM-P1/P2 Difference



DM-P1
More detail/noise

DM-P2
Less detail/noise

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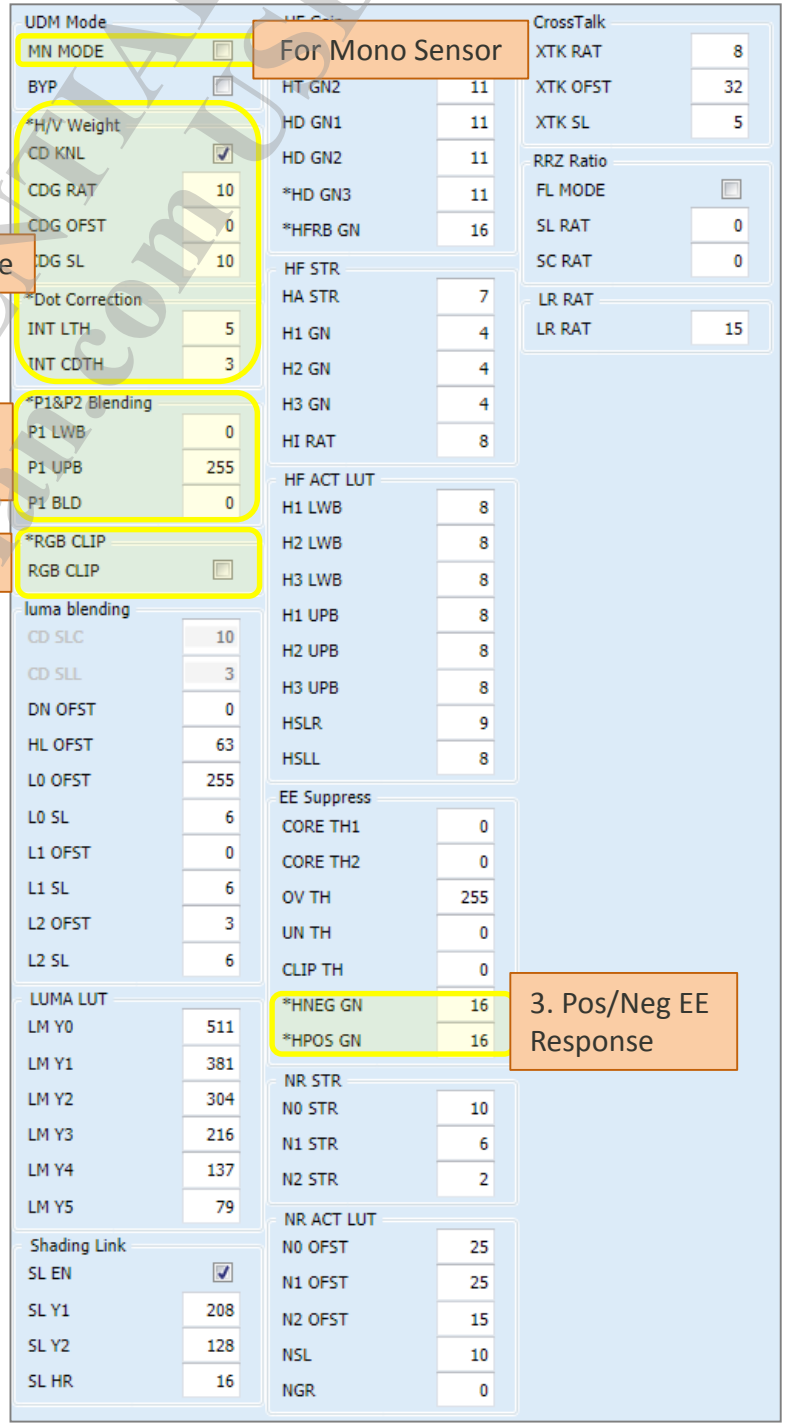
P40 DM New Features

Items
1. DM-P1 Upgrade
2. DM-P1&DM-P2 Blending
3. Pos/Neg EE Response
4. Clipping Recovery



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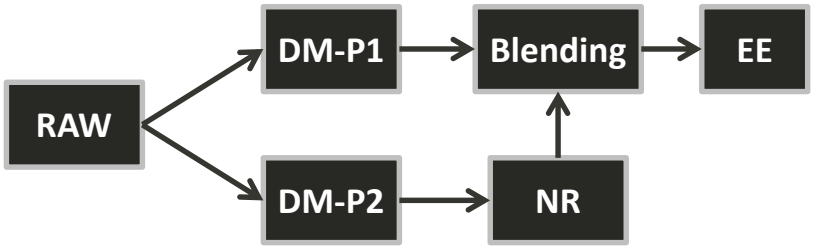
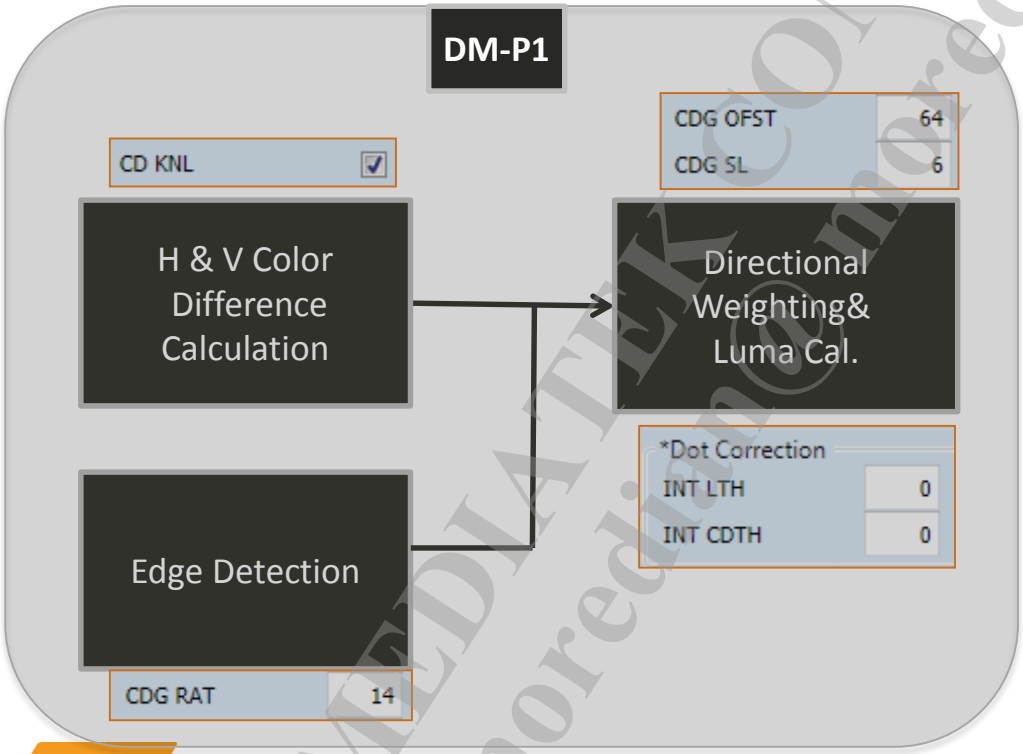
1. DM-P1 Upgrade





UDM Mode	
MN MODE	
BYP	
*H/V Weight	
CD KNL	☑
CDG RAT	10
CDG OFST	0
CDG SL	10
*Dot Correction	
INT LTH	5
INT CDTH	3
*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	0
*RGB CLIP	
RGB CLIP	
luma blending	
CD SLC	10
CD SLL	3
DN OFST	0
HL OFST	63
L0 OFST	255
L0 SL	6
L1 OFST	0
L1 SL	6
L2 OFST	3
L2 SL	6
LUMA LUT	
LM Y0	511
LM Y1	381
LM Y2	304
LM Y3	216
LM Y4	137
LM Y5	79
Shading Link	
SL EN	☑
SL Y1	208
SL Y2	128
SL HR	16

HF Gain	
HT GN1	11
HT GN2	11
HD GN1	11
HD GN2	11
*HD GN3	11
*HFRB GN	16
HF STR	
HA STR	7
H1 GN	4
H2 GN	4
H3 GN	4
HI RAT	8
HF ACT LUT	
H1 LWB	8
H2 LWB	8
H3 LWB	8
H1 UPB	8
H2 UPB	8
H3 UPB	8
HSLR	9
HSLL	8
EE Suppress	
CORE TH1	0
CORE TH2	0
OV TH	255
UN TH	0
CLIP TH	0
*HNEG GN	16
*HPOS GN	16
NR STR	
N0 STR	10
N1 STR	6
N2 STR	2
NR ACT LUT	
N0 OFST	25
N1 OFST	25
N2 OFST	15
NSL	10
NGR	0

CrossTalk	
XTK RAT	8
XTK OFST	32
XTK SL	5
RRZ Ratio	
FL MODE	
SL RAT	0
SC RAT	0
LR RAT	
LR RAT	15

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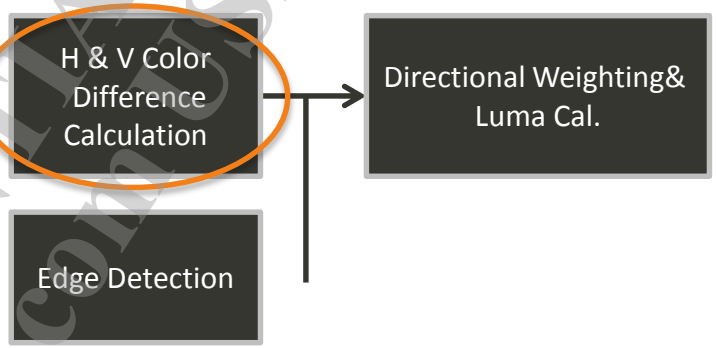
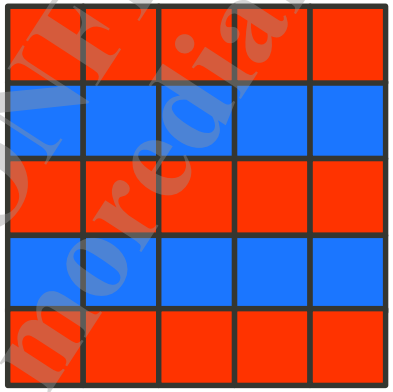
1.1 H/V Color Difference Calculation

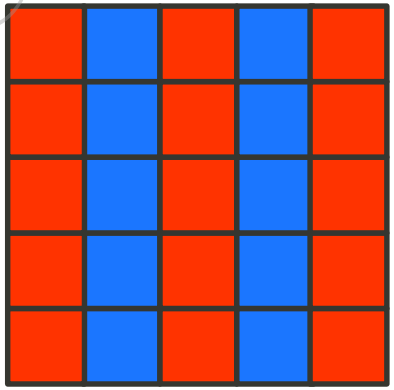


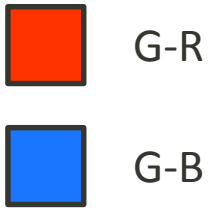
raw

CD^H



CD^V





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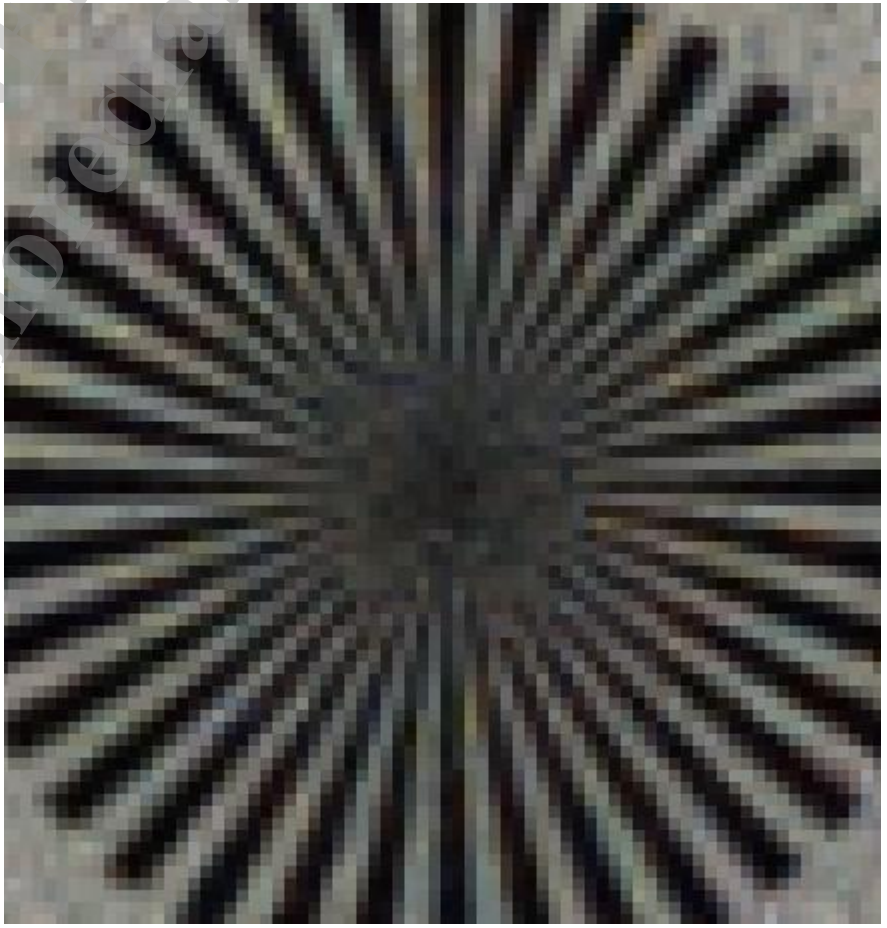
CD_KNL = 0

Show Pure DM1 Result →

*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



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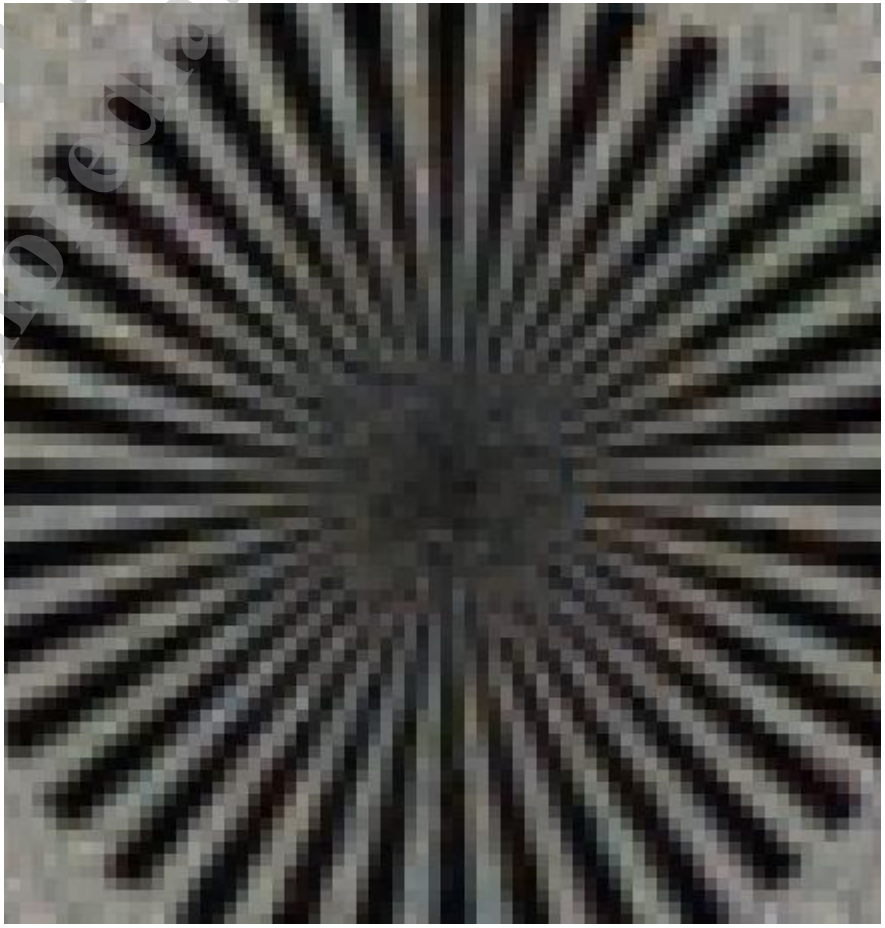
mordian@mediatek.com

CD_KNL = 1 (※ Default, No Need to Tune)

Show Pure DM1 Result →

*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



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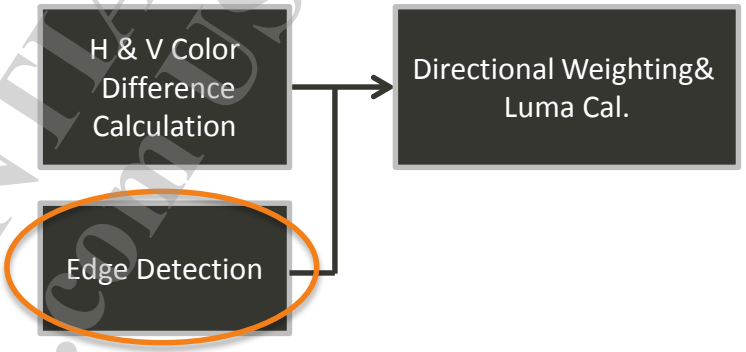
1.2 Edge Detection



- For each pixel, detect its weighting of horizontal gradient (**W_H**) and vertical gradient (**W_V**) by neighbor pixels.
- Two detection methods are used

  CDG_RAT is used to decide the ratio of large kernel method result.

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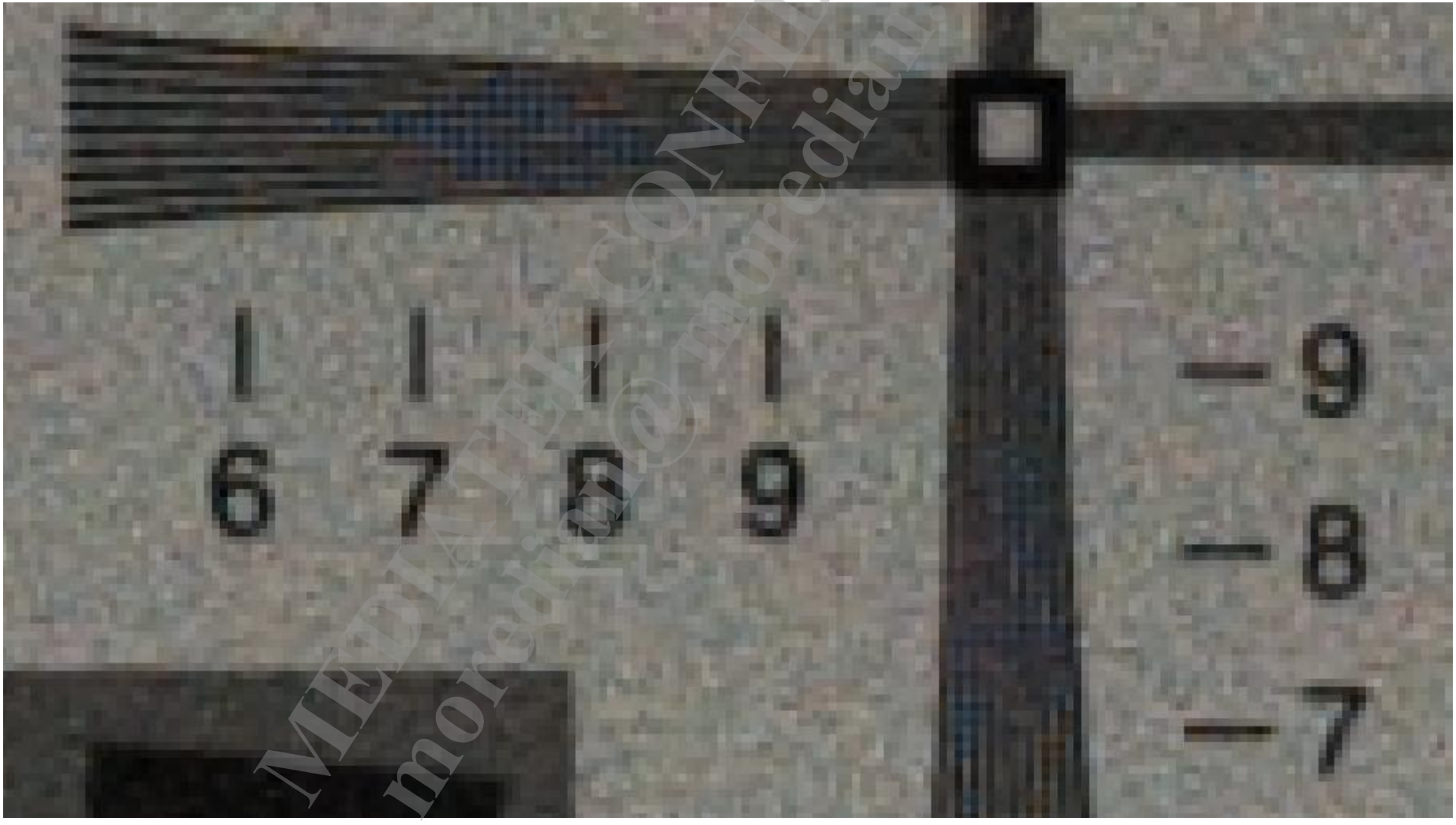
CDG_RAT = 16

CDG OFST	0
CDG SL	6

*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



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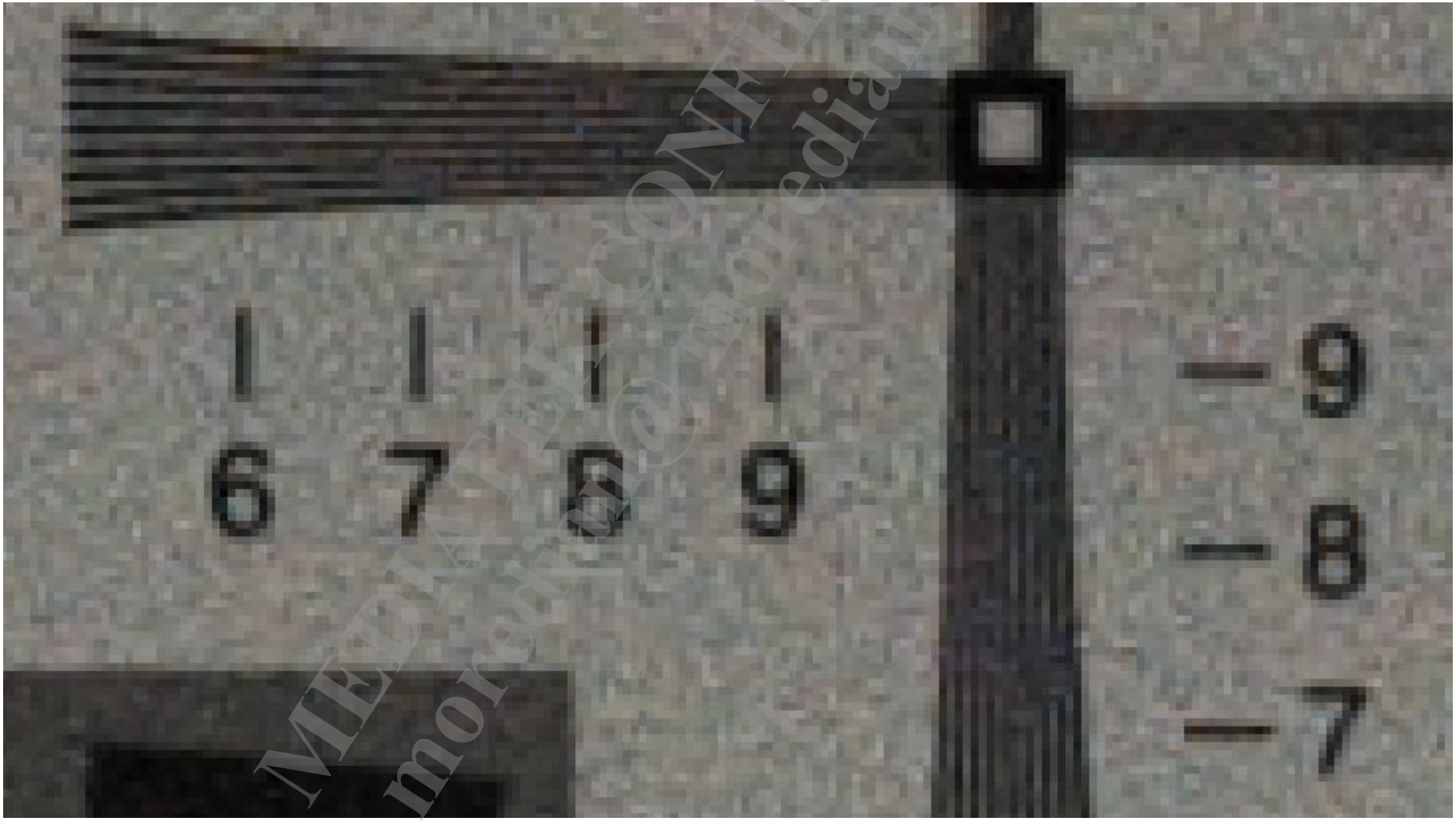
CDG_RAT = 14

CDG OFST	0
CDG SL	6

*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



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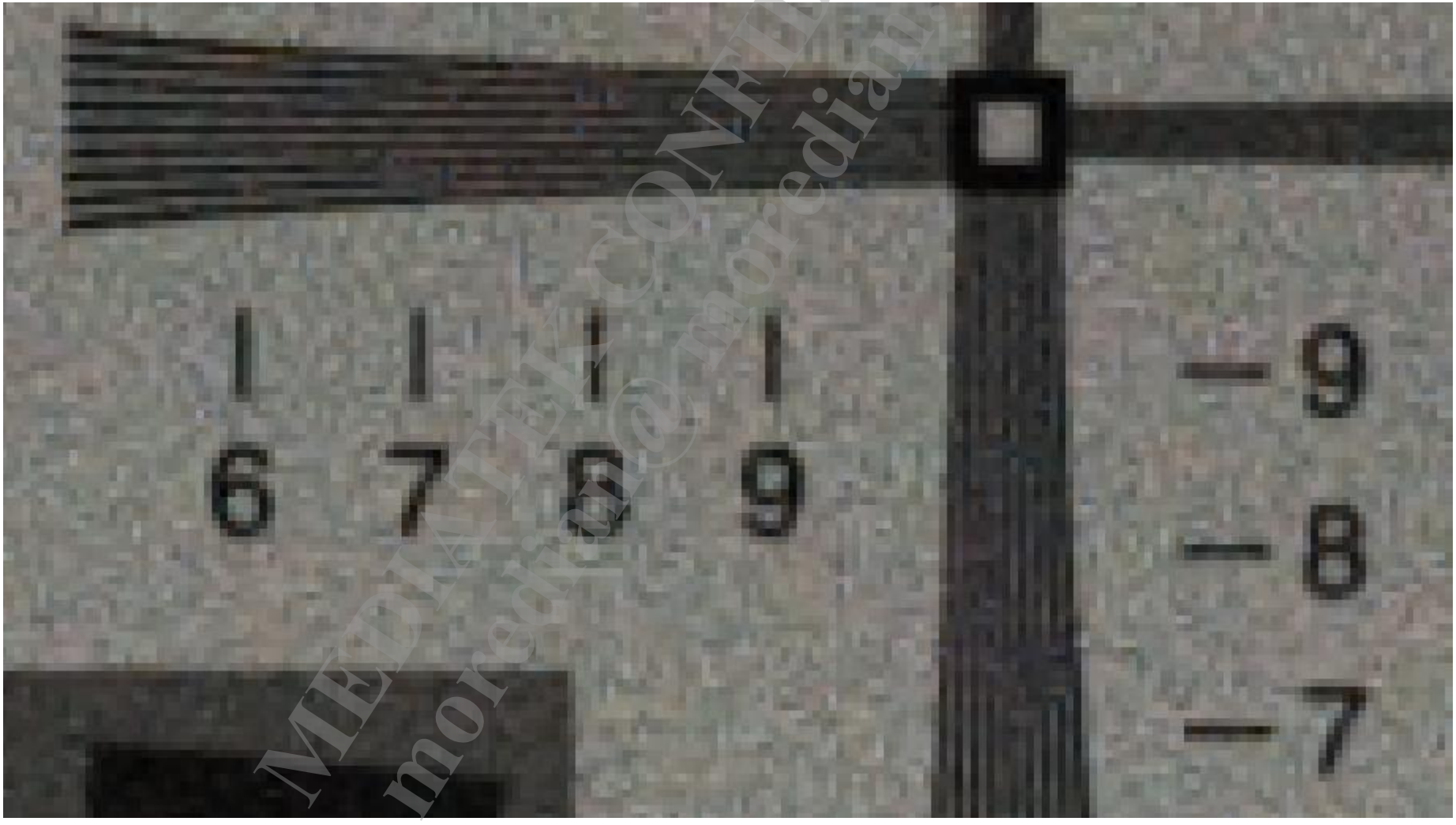
CDG_RAT = 12 (※ Preferred)

CDG OFST	0
CDG SL	6

*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



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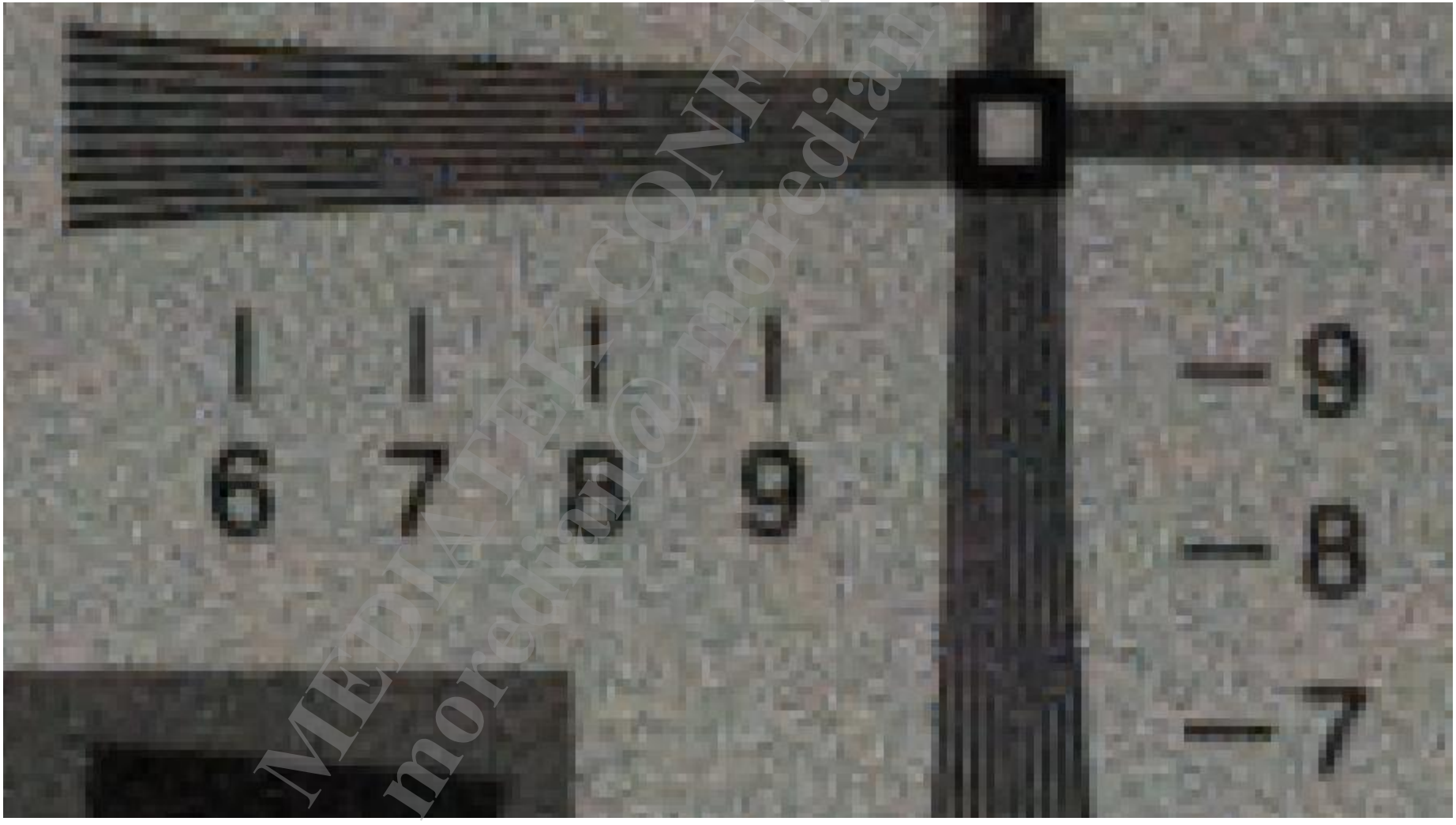
CDG_RAT = 8

CDG OFST	0
CDG SL	6

*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



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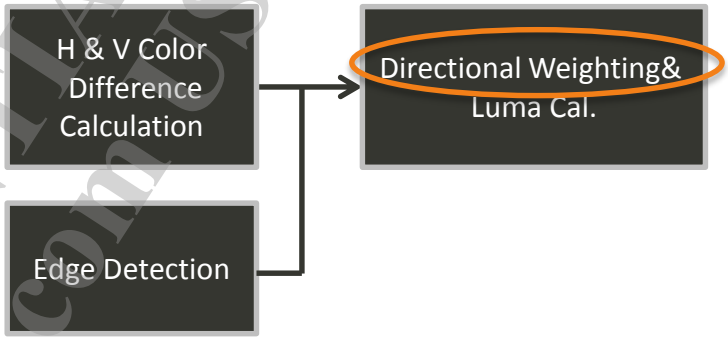
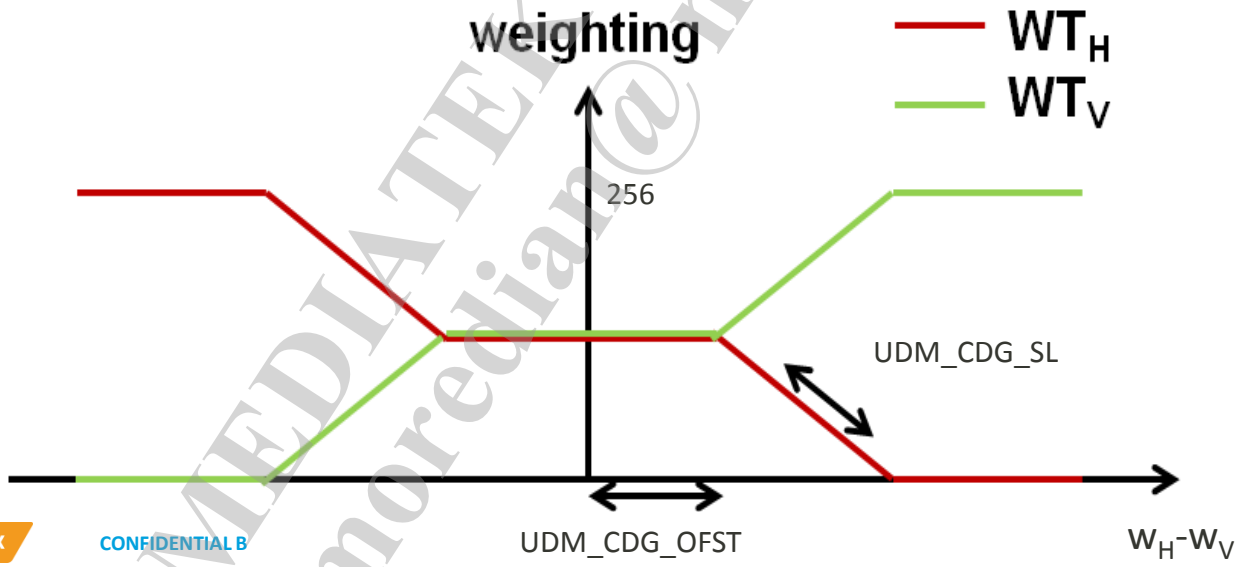
1.3 Weighting CD



- Final Color Difference (CD) is adaptive combined by

  Horizontal Gradient Weighting (**W_H**) and Vertical Gradient Weighting (**W_V**)



CDG OFST	0
CDG SL	6

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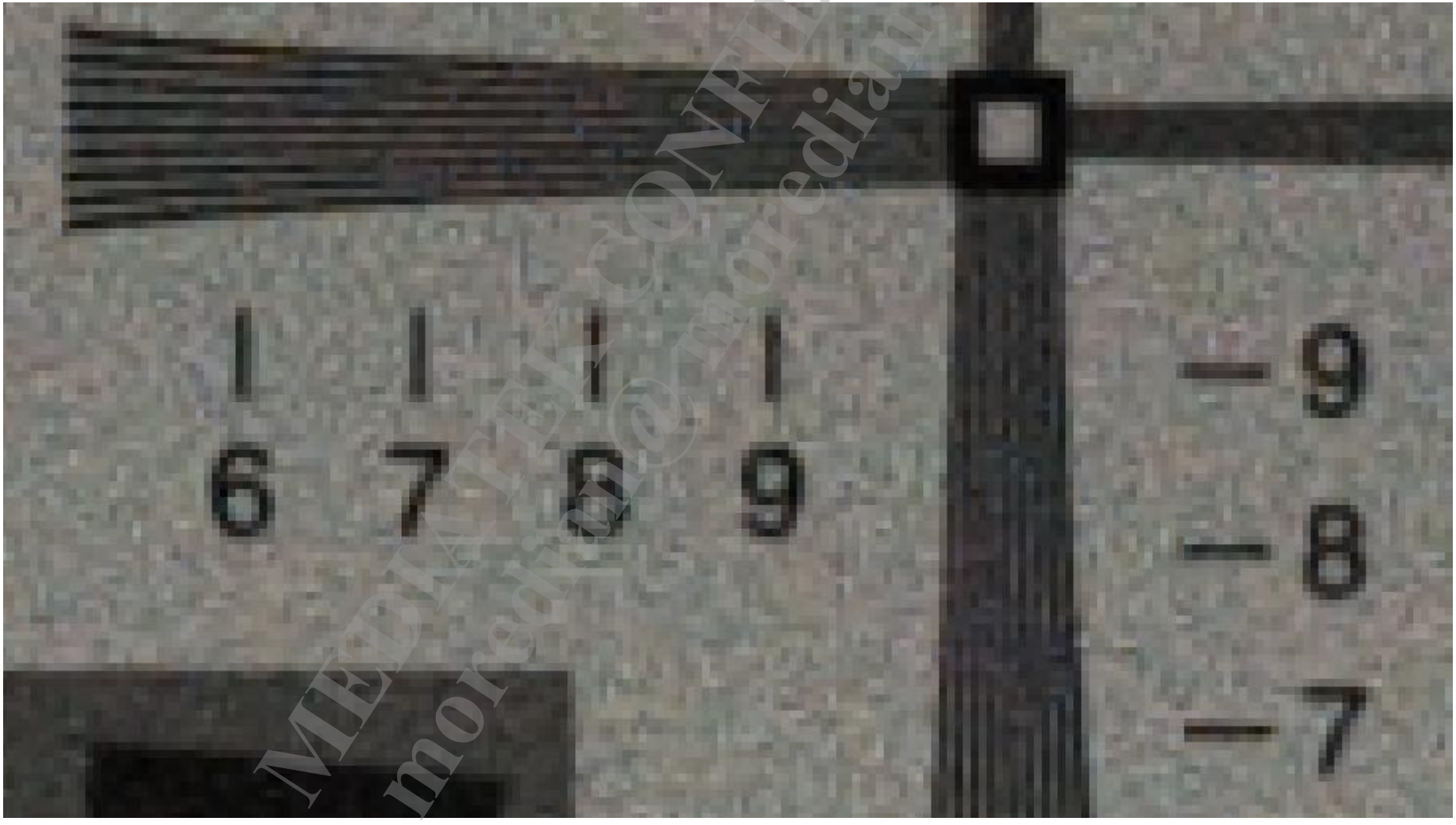
CDG_OFST = 0 (※ Preferred)

CDG RAT	14
CDG SL	6

*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



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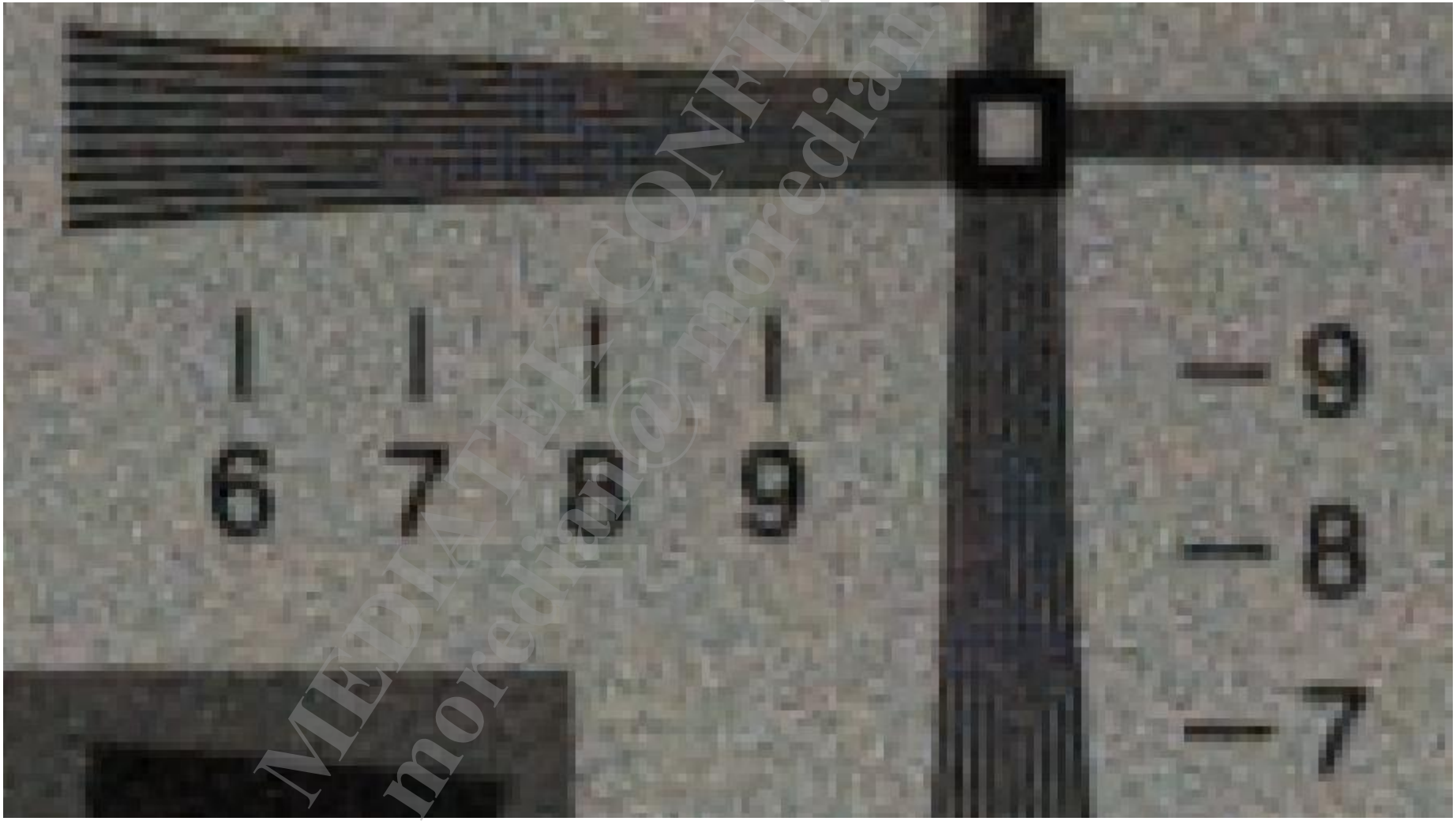
CDG_OFST = 32

CDG RAT	14
CDG SL	6

*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



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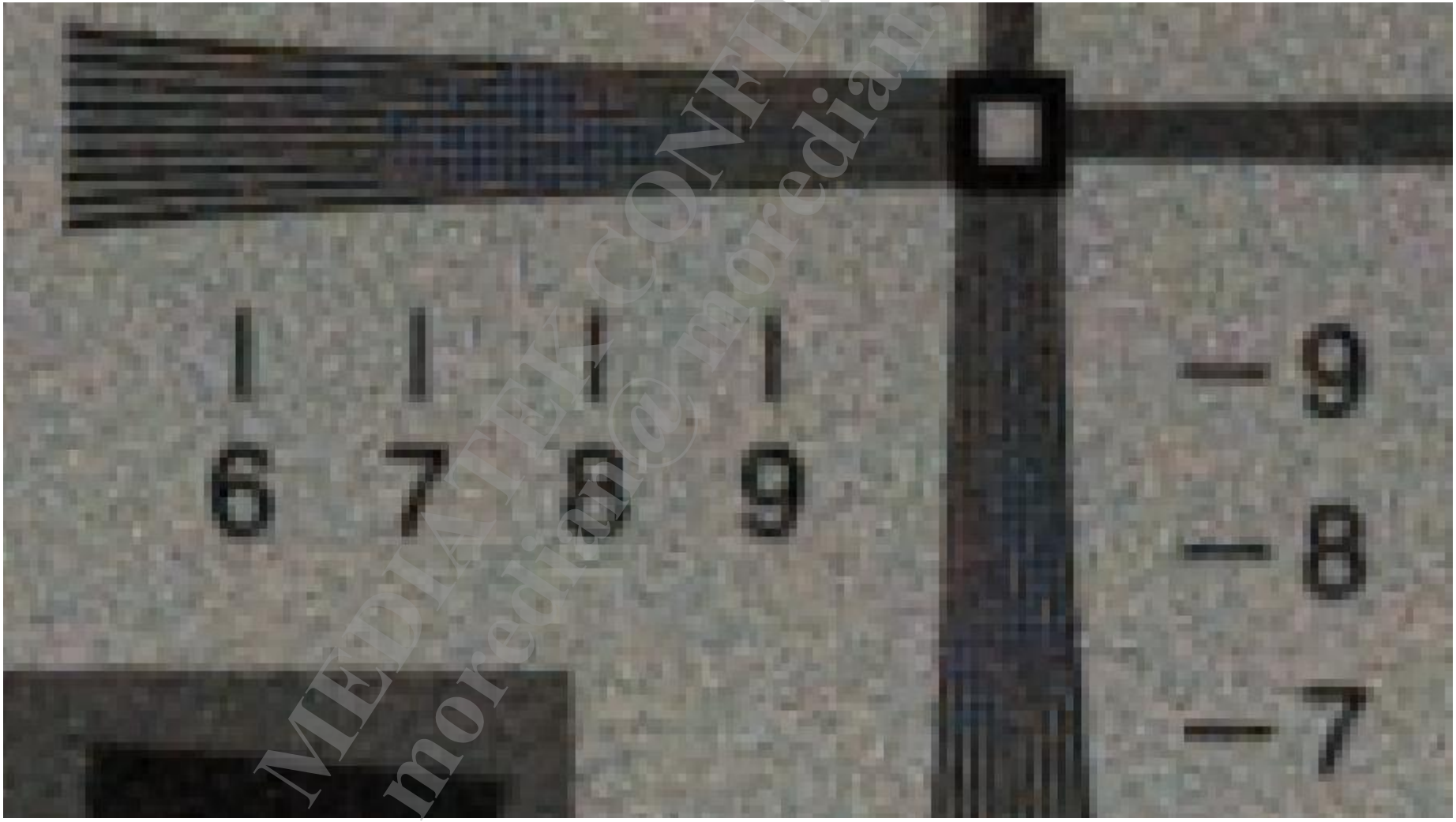
CDG_OFST = 64

CDG RAT	14
CDG SL	6

*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



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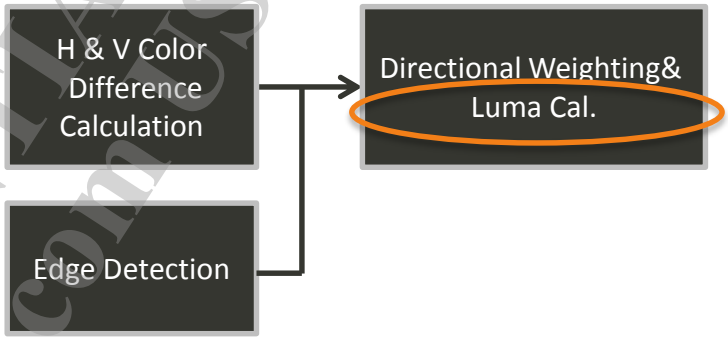
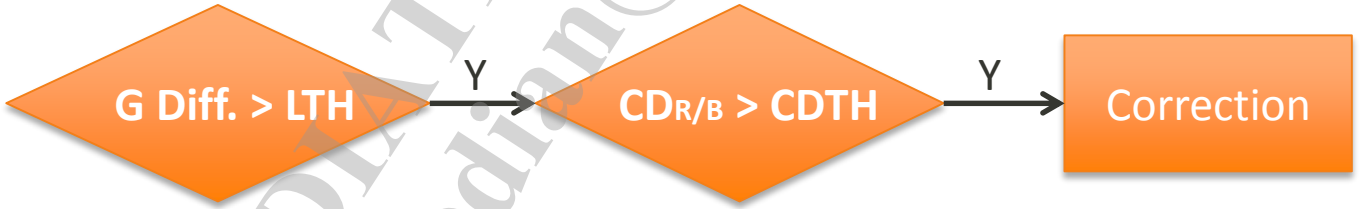
1.4 Luma Calculation



- For each pixel in Bayer domain, estimate lacked channel by CD values (G/R & G/B)

- Single Dot Correction
  - If estimated G value is identified as impulse noise, correct it by surrounding G channel pixels.



※ Default: LTH = 3, CDTH=5

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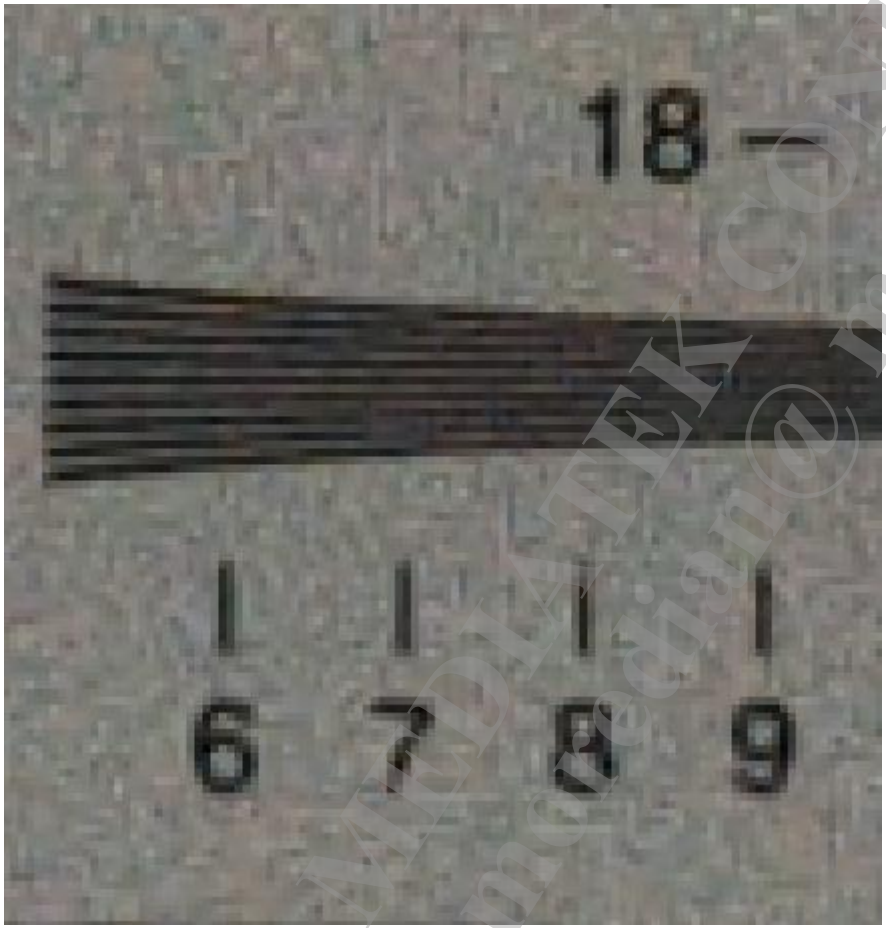
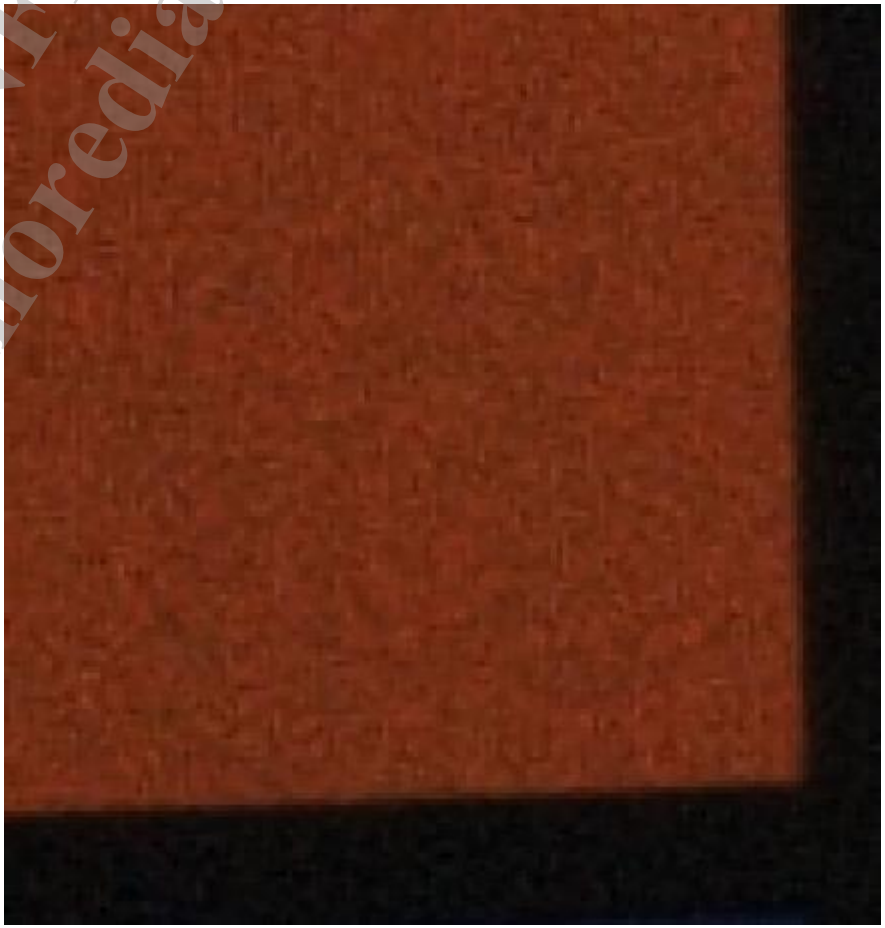
Strong Dot Correction (※ Default)

*Dot Correction	
INT LTH	3
INT CDTH	5





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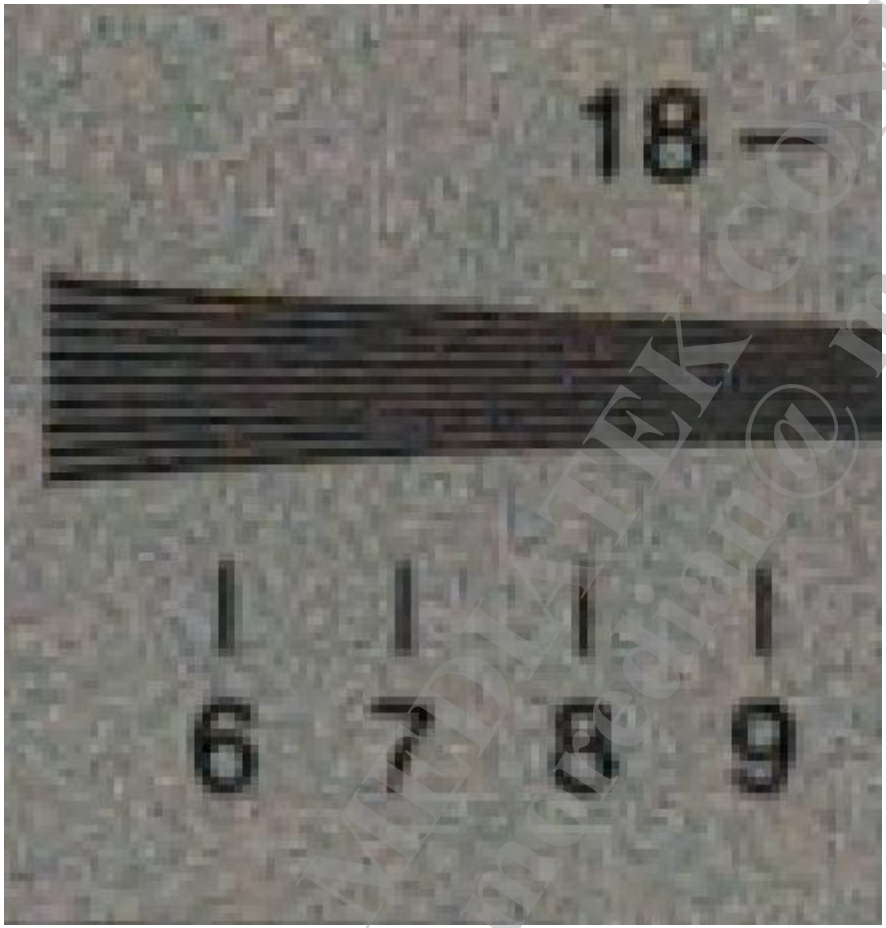
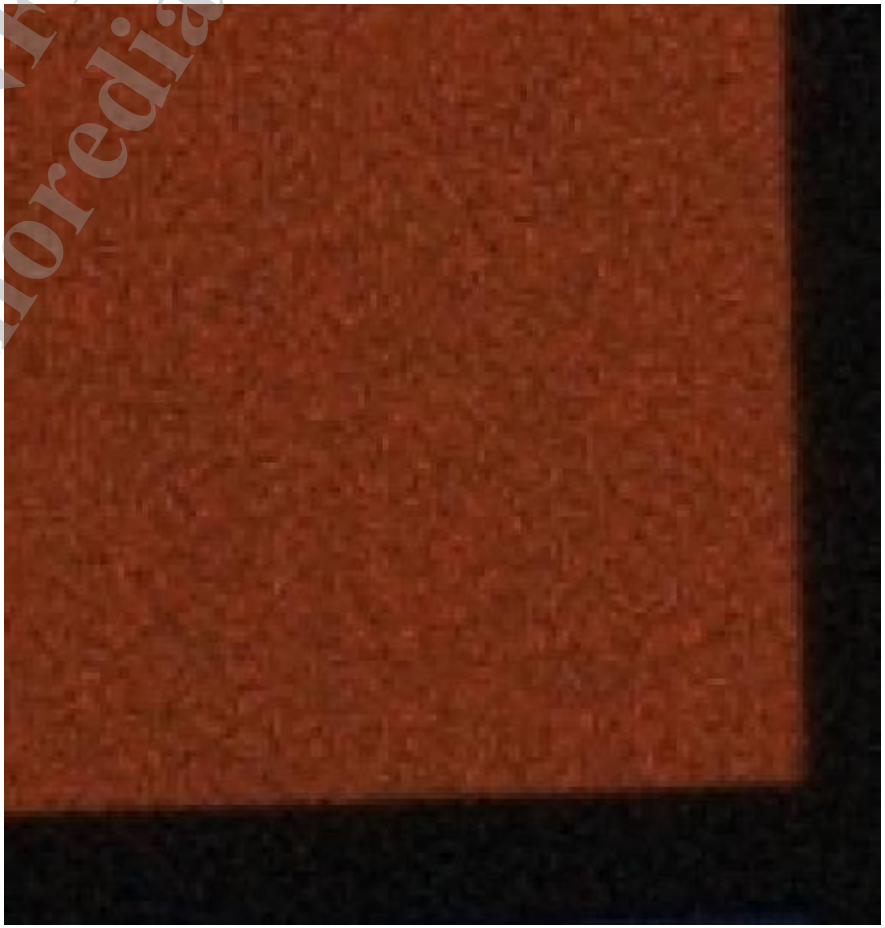
Weak Dot Correction

*Dot Correction

INT LTH	15
INT CDTH	15





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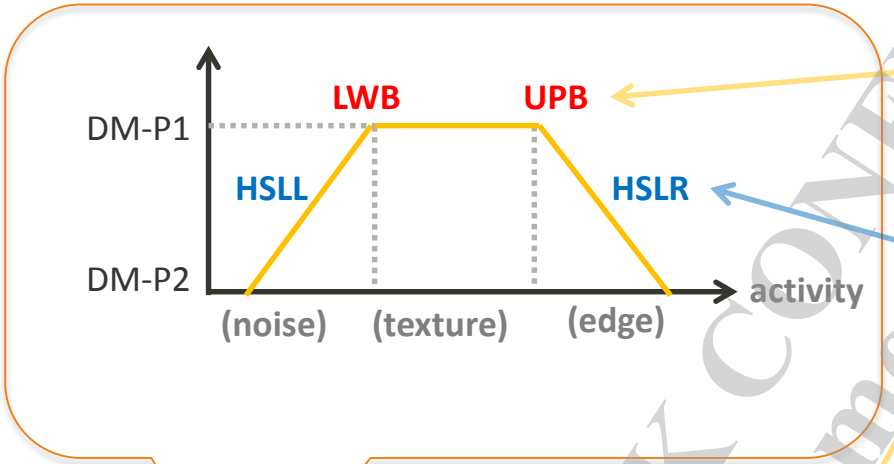
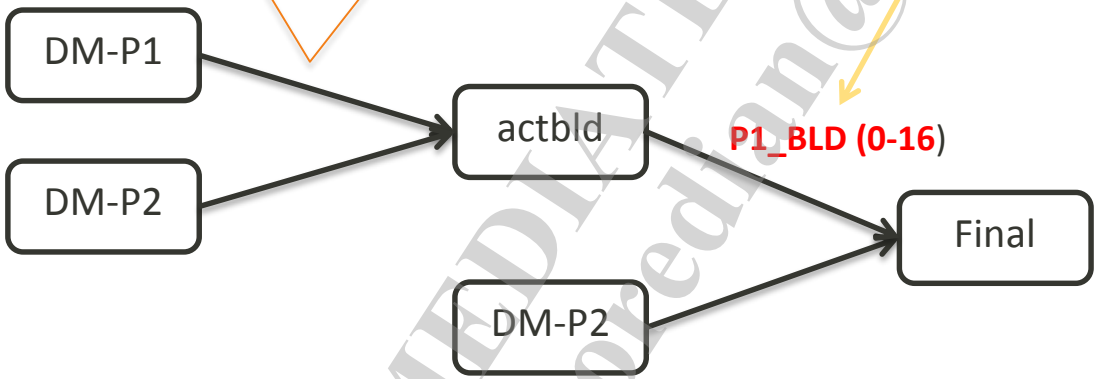
2. DM-P1 & DM-P2 Blending





UDM Mode	
MN MODE	
BYP	
*H/V Weight	
CD KNL	☑
CDG RAT	10
CDG OFST	0
CDG SL	10
*Dot Correction	
INT LTH	5
INT CDTH	3
*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	0
*RGB CLIP	
RGB CLIP	
luma blending	
CD SLC	10
CD SLL	3
DN OFST	0
HL OFST	63
L0 OFST	255
L0 SL	6
L1 OFST	0
L1 SL	6
L2 OFST	3
L2 SL	6
LUMA LUT	
LM Y0	511
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LM Y2	304
LM Y3	216
LM Y4	137
LM Y5	79
Shading Link	
SL EN	☑
SL Y1	208
SL Y2	128
SL HR	16

HF Gain	
HT GN1	11
HT GN2	11
HD GN1	11
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*HD GN3	11
*HFRB GN	16
HF STR	
HA STR	7
H1 GN	4
H2 GN	4
H3 GN	4
HI RAT	8
HF ACT LUT	
H1 LWB	8
H2 LWB	8
H3 LWB	8
H1 UPB	8
H2 UPB	8
H3 UPB	8
HSLR	9
HSLL	8
EE Suppress	
CORE TH1	0
CORE TH2	0
OV TH	255
UN TH	0
CLIP TH	0
*HNEG GN	16
*HPOS GN	16
NR STR	
N0 STR	10
N1 STR	6
N2 STR	2
NR ACT LUT	
N0 OFST	25
N1 OFST	25
N2 OFST	15
NSL	10
NGR	0

CrossTalk	
XTK RAT	8
XTK OFST	32
XTK SL	5
RRZ Ratio	
FL MODE	
SL RAT	0
SC RAT	0
LR RAT	
LR RAT	15

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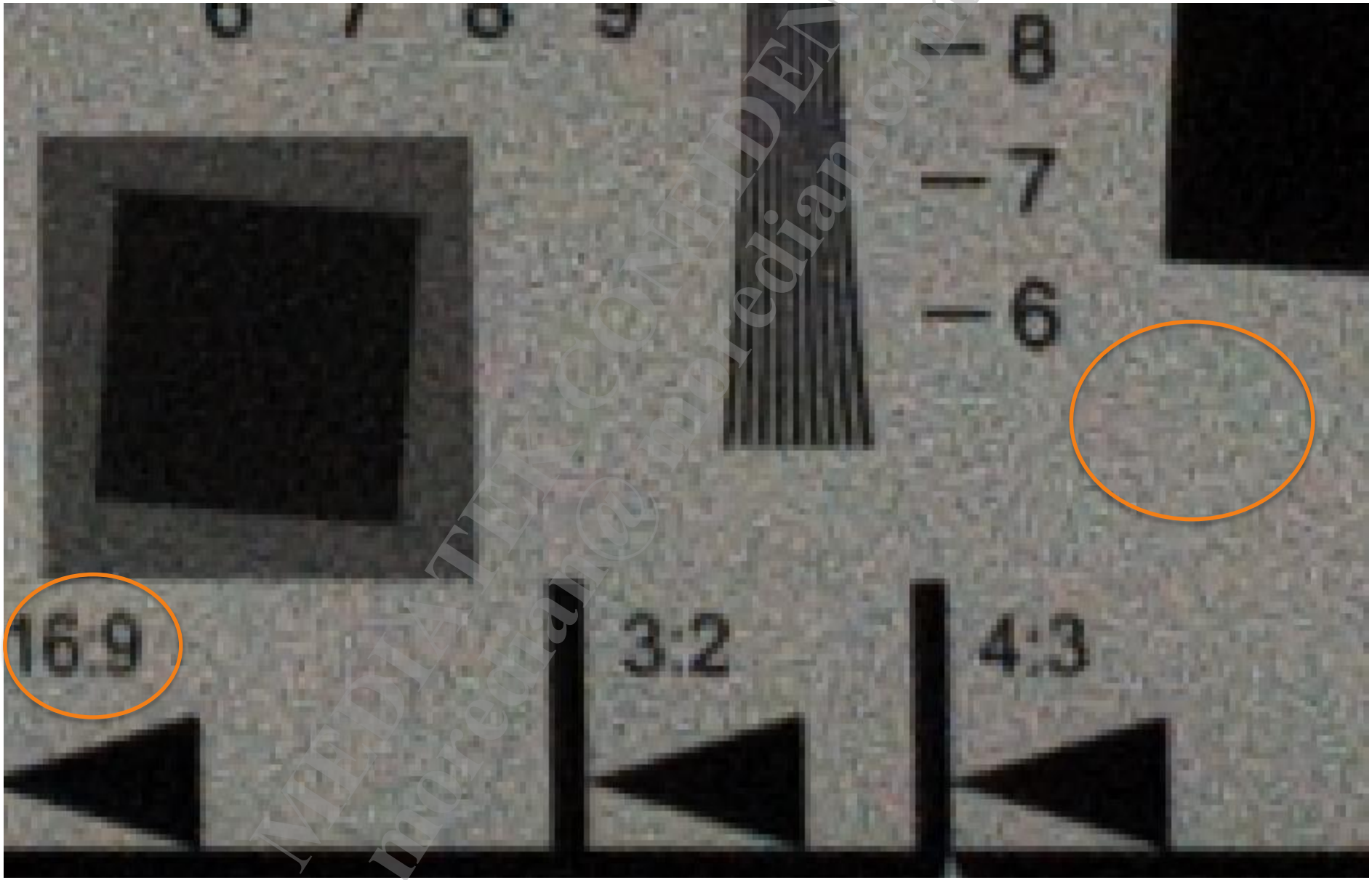
*P1&P2 Blending

P1 LWB	0
P1 UPB	255
P1 BLD	16

DM-P1 Result

(Noisy)



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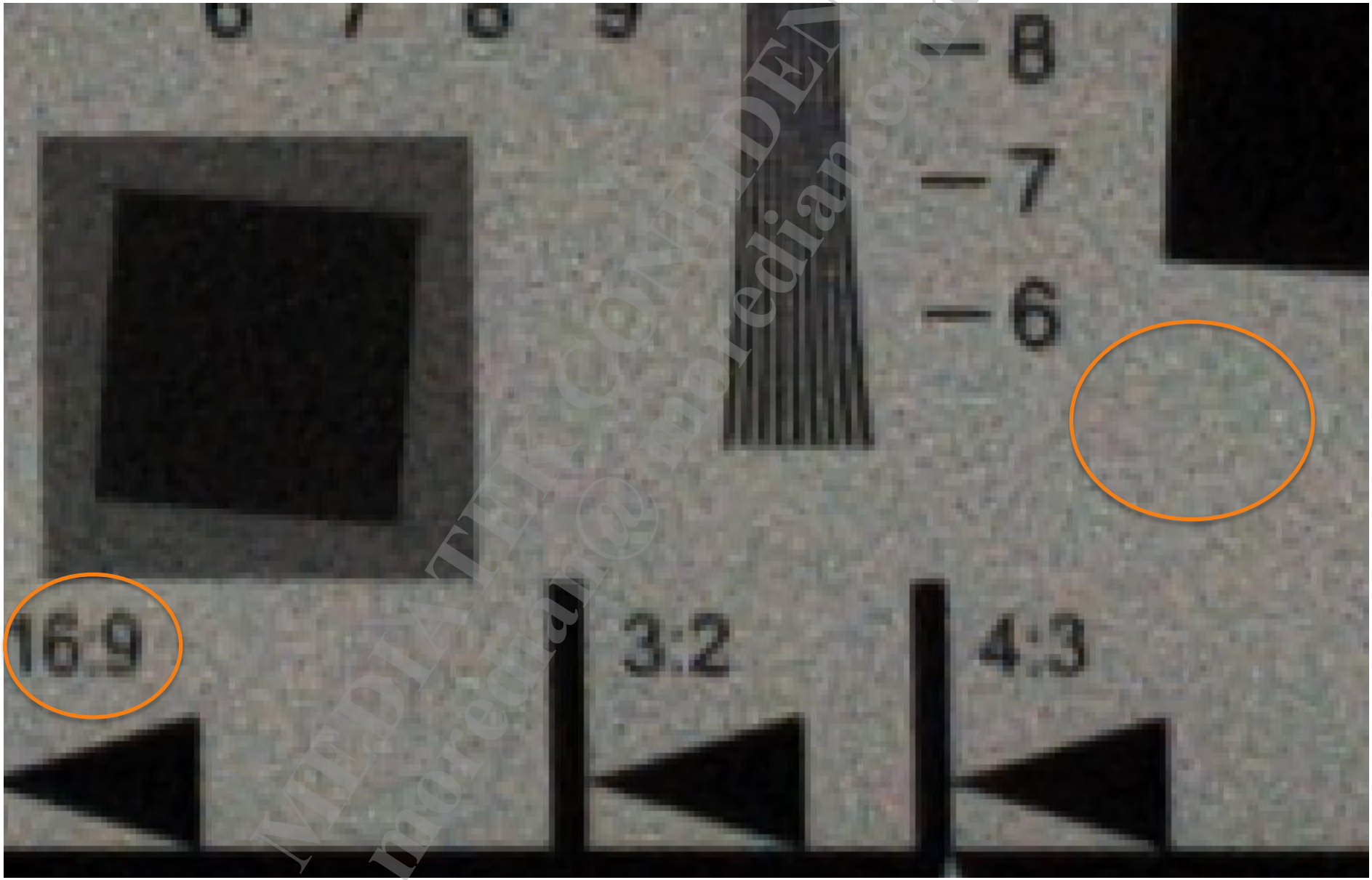
*P1&P2 Blending

P1 LWB	0
P1 UPB	255
P1 BLD	0

DM-P2 Result

(Blurry Texture)



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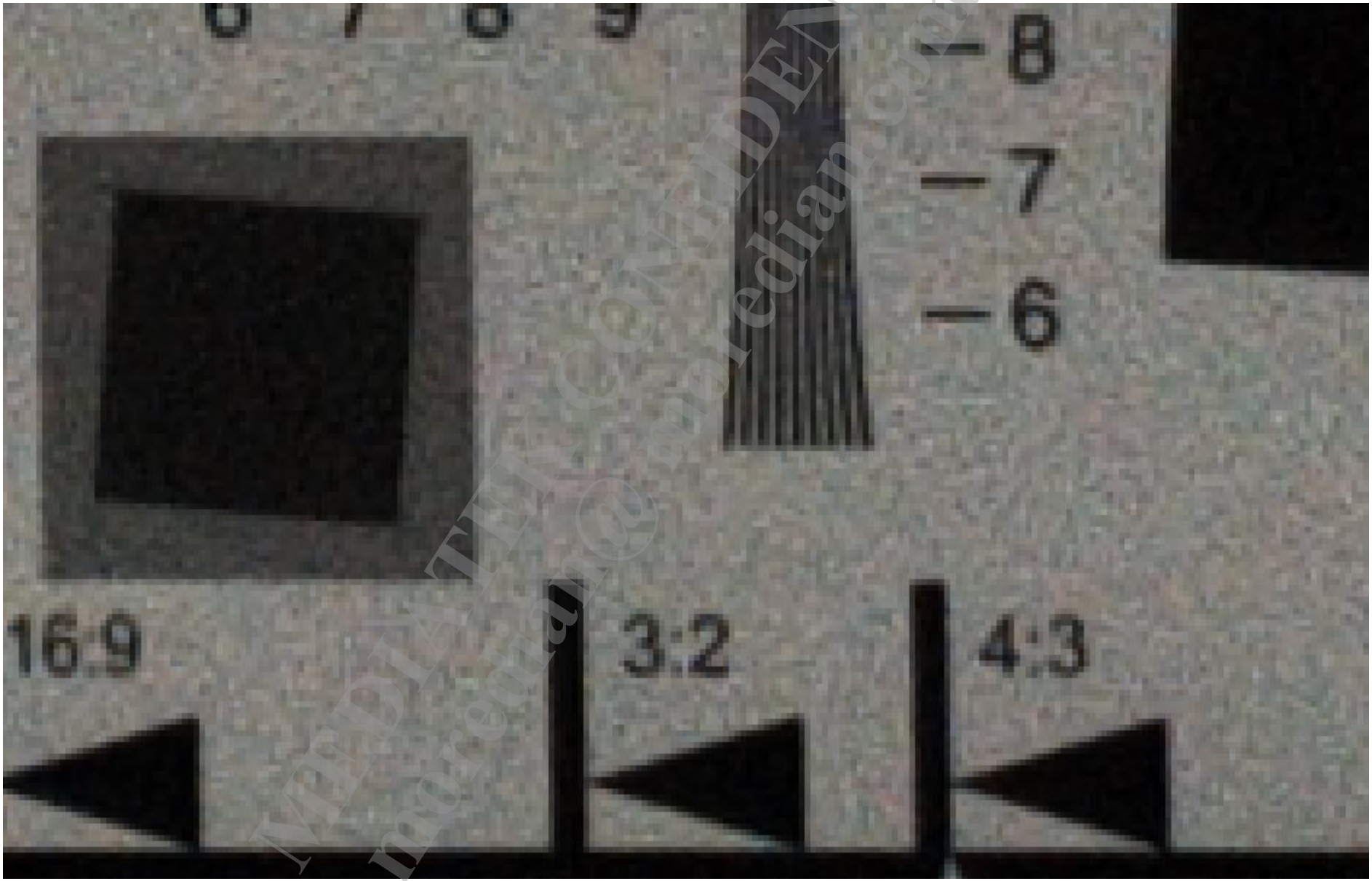
*P1&P2 Blending

P1 LWB	0
P1 UPB	255
P1 BLD	8

½ DM-P1 + ½ DM-P2



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Blending Tuning Flow

1. Set P2 as initial result since it's close to P23

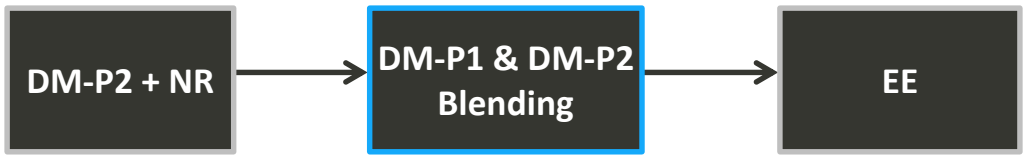
P1 BLD	0

2. If more details is needed, tune DM1 as said above

*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16

3. Blend DM-P1 and DM-P2 based on detail/noise preference
   Set P1 LWB/UPB as H1 LWB/UPB by default

※Note: UDM NR can only be applied on DM2



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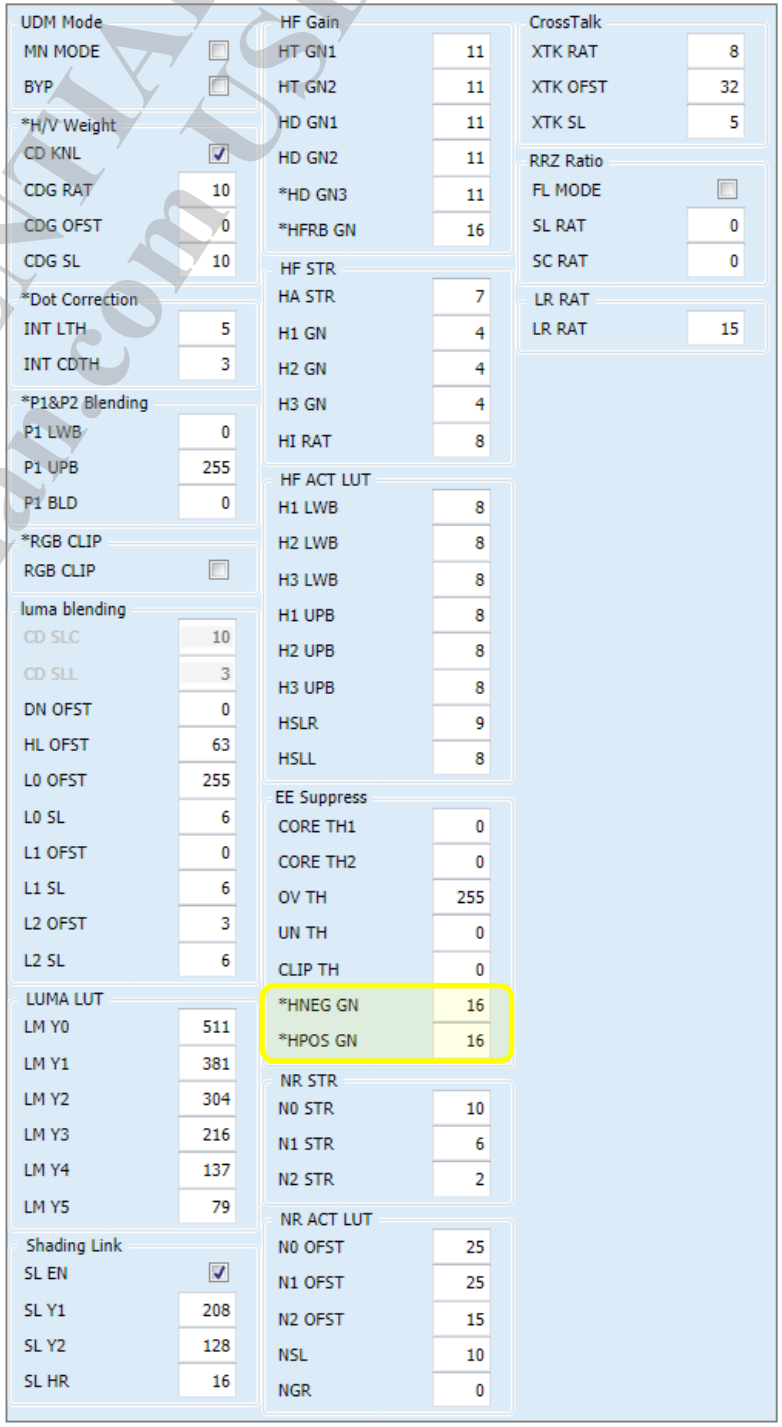
3. Positive/Negative EE Response

To suppress overshoot or undershoot separately



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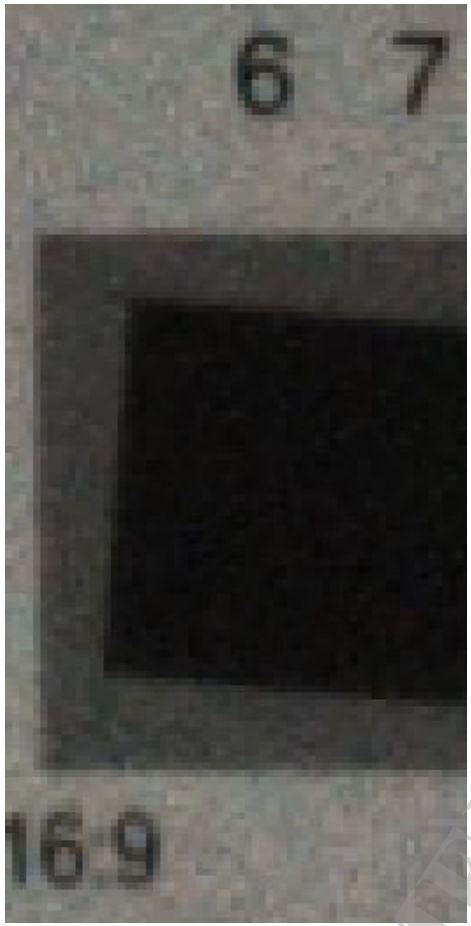
(※ Default)

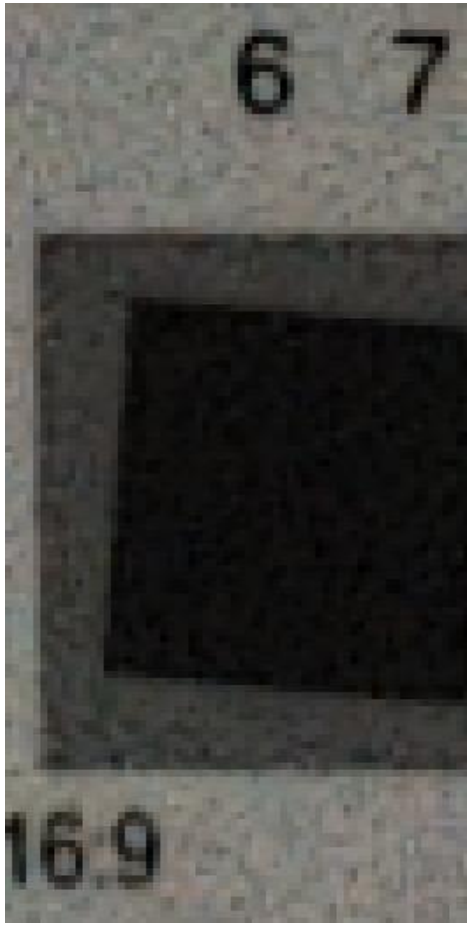
HNEG_GN = 0
HPOS_GN = 0



HNEG_GN = 16
HPOS_GN = 16

HNEG_GN = 0
HPOS_GN = 16

HNEG_GN = 16
HPOS_GN = 0



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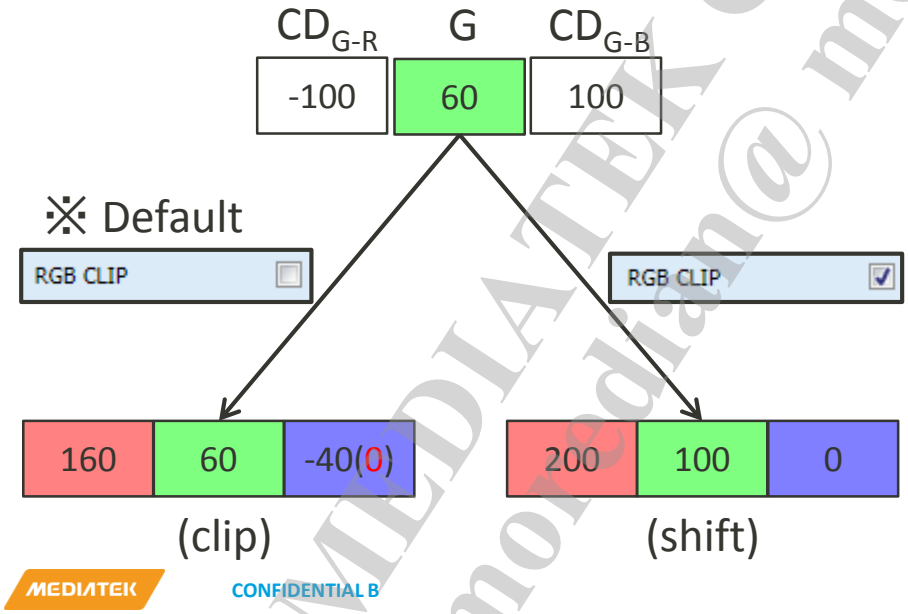
4. RGB Clipping Recovery

When minus value happens,
shift RGB to positive instead of clipping

(Usually happens in dark red/blue area)



UDM Mode		HF Gain		CrossTalk	
MN MODE	☐	HT GN1	11	XTK RAT	8
BYP	☐	HT GN2	11	XTK OFST	32
*H/V Weight		HD GN1	11	XTK SL	5
CD KNL	☑	HD GN2	11	RRZ Ratio	
CDG RAT	10	*HD GN3	11	FL MODE	☐
CDG OFST	0	*HFRB GN	16	SL RAT	0
CDG SL	10	HF STR		SC RAT	0
*Dot Correction		HA STR	7	LR RAT	
INT LTH	5	H1 GN	4	LR RAT	15
INT CDTH	3	H2 GN	4		
*P1&P2 Blending		H3 GN	4		
P1 LWB	0	HI RAT	8		
P1 UPB	255	HF ACT LUT			
P1 BLD	0	H1 LWB	8		
*RGB CLIP		H2 LWB	8		
RGB CLIP	☐	H3 LWB	8		
luma blending		H1 UPB	8		
CD SLC	10	H2 UPB	8		
CD SLL	3	H3 UPB	8		
DN OFST	0	HSLR	9		
HL OFST	63	HSLL	8		
L0 OFST	255	EE Suppress			
L0 SL	6	CORE TH1	0		
L1 OFST	0	CORE TH2	0		
L1 SL	6	OV TH	255		
L2 OFST	3	UN TH	0		
L2 SL	6	CLIP TH	0		
LUMA LUT		*HNEG GN	16		
LM Y0	511	*HPOS GN	16		
LM Y1	381	NR STR			
LM Y2	304	N0 STR	10		
LM Y3	216	N1 STR	6		
LM Y4	137	N2 STR	2		
LM Y5	79	NR ACT LUT			
Shading Link		N0 OFST	25		
SL EN	☑	N1 OFST	25		
SL Y1	208	N2 OFST	15		
SL Y2	128	NSL	10		
SL HR	16	NGR	0		

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Clipping Recovery OFF

RGB CLIP

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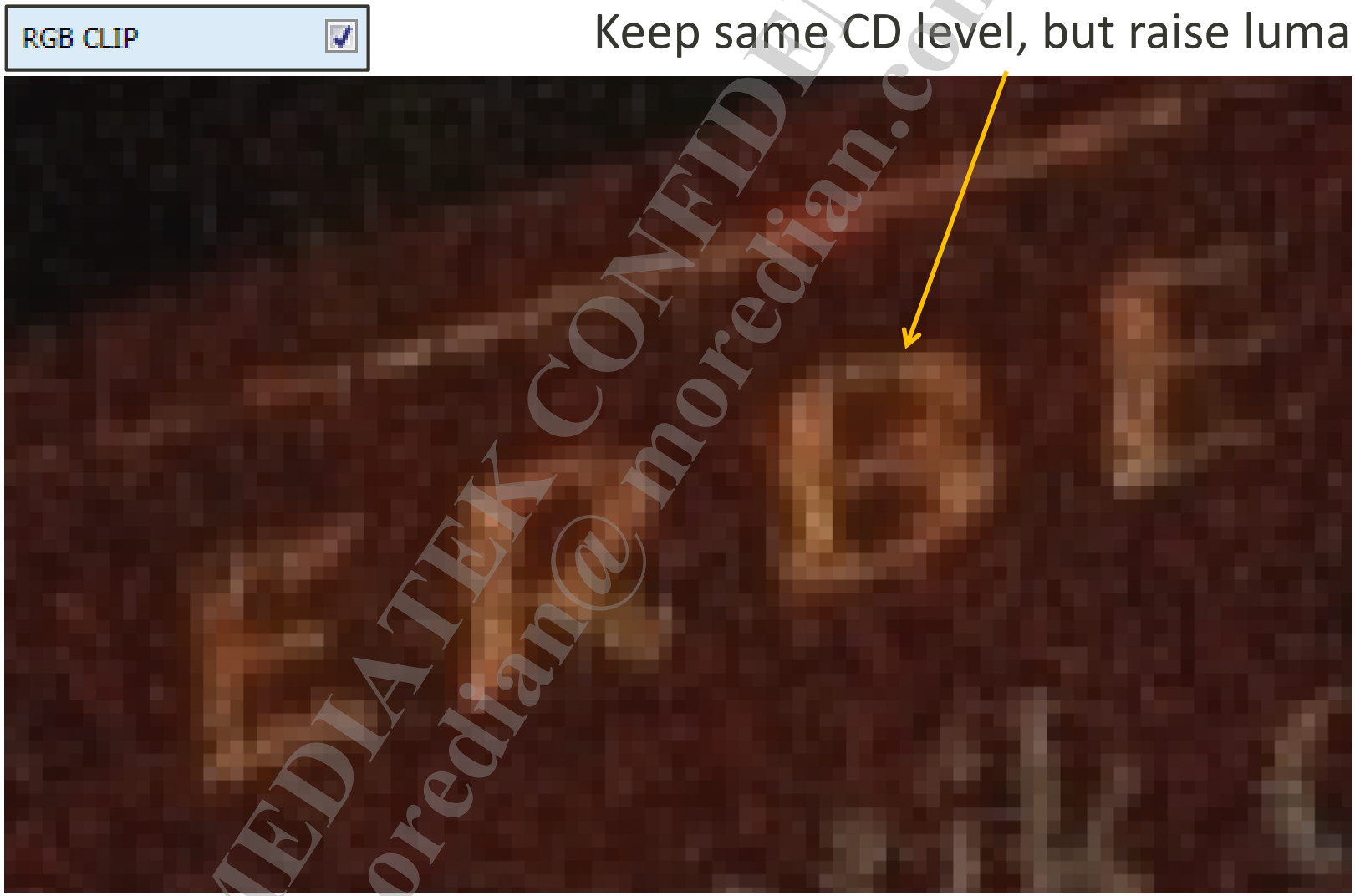
Clipping Recovery ON



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Outline

- DM Improvement
  - DM-P1 Upgrade
  - DM-P1&DM-P2 Blending
  - Pos/Neg EE Response
  - Clipping Recovery
- **EE Improvement**
  - HP smoothing
  - YCE/CCE
  - Slow transition
  - Chroma Boost
  - Coring by Band
  - Pos/Neg Gain
  - PBC

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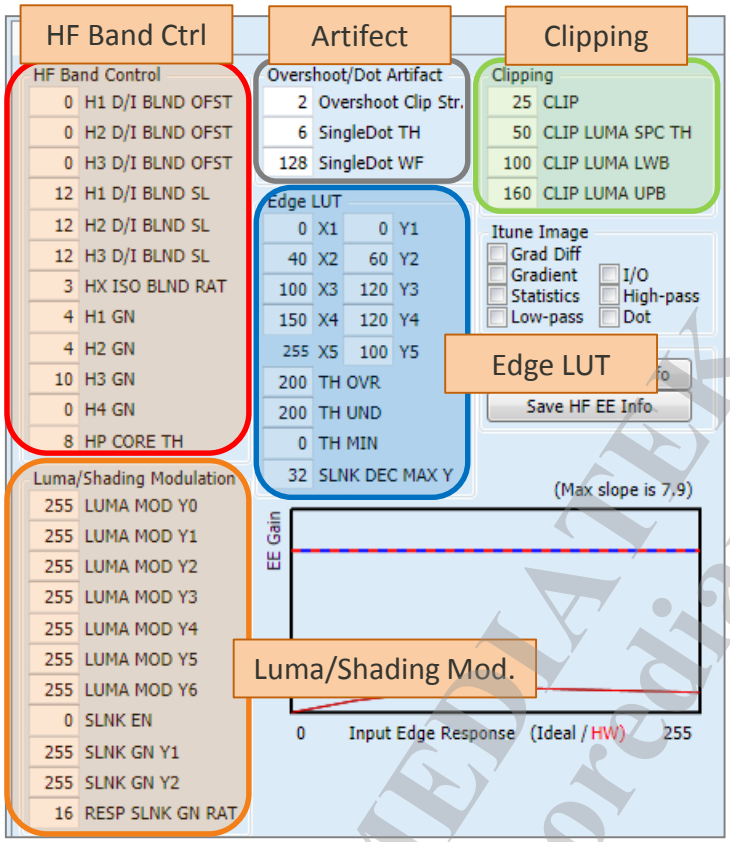
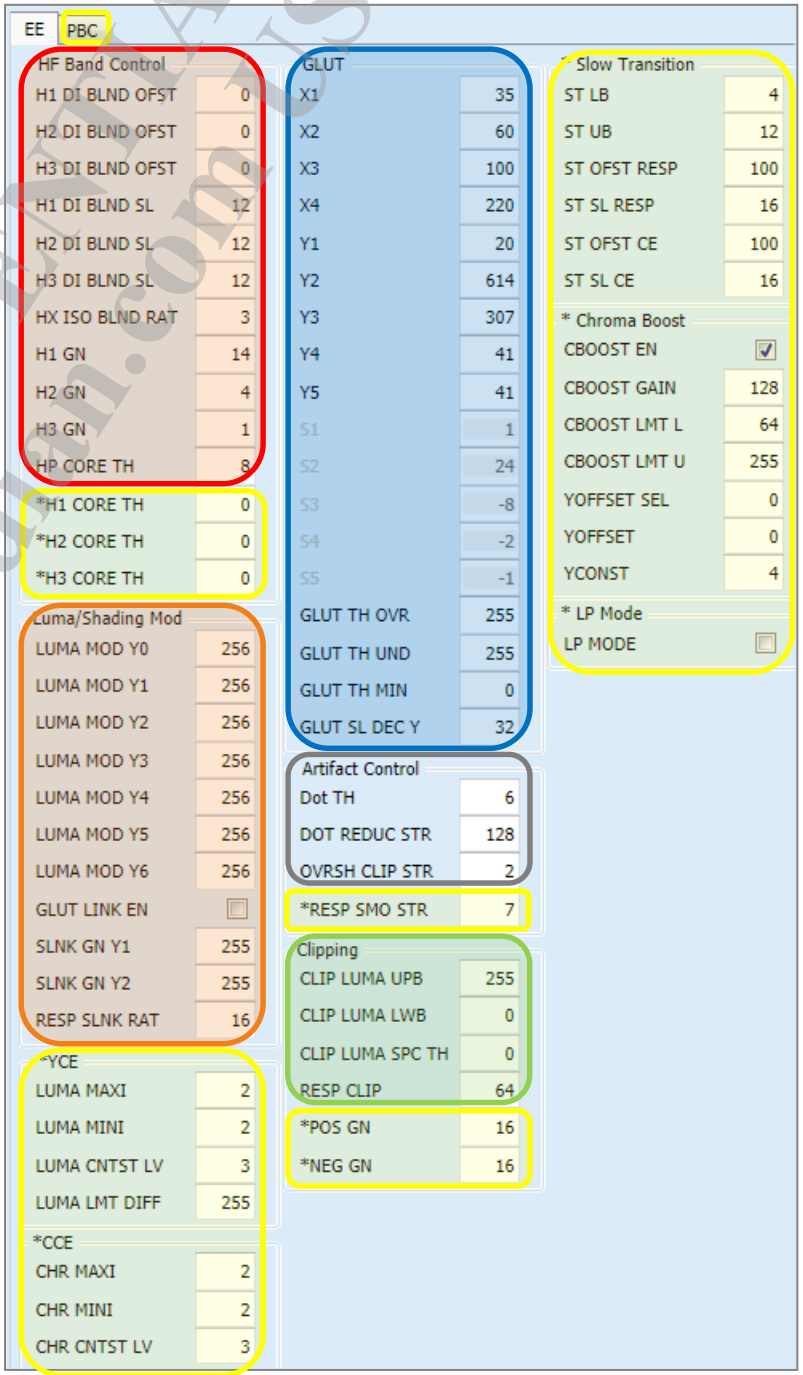
P23 EE ➡ P40 EE





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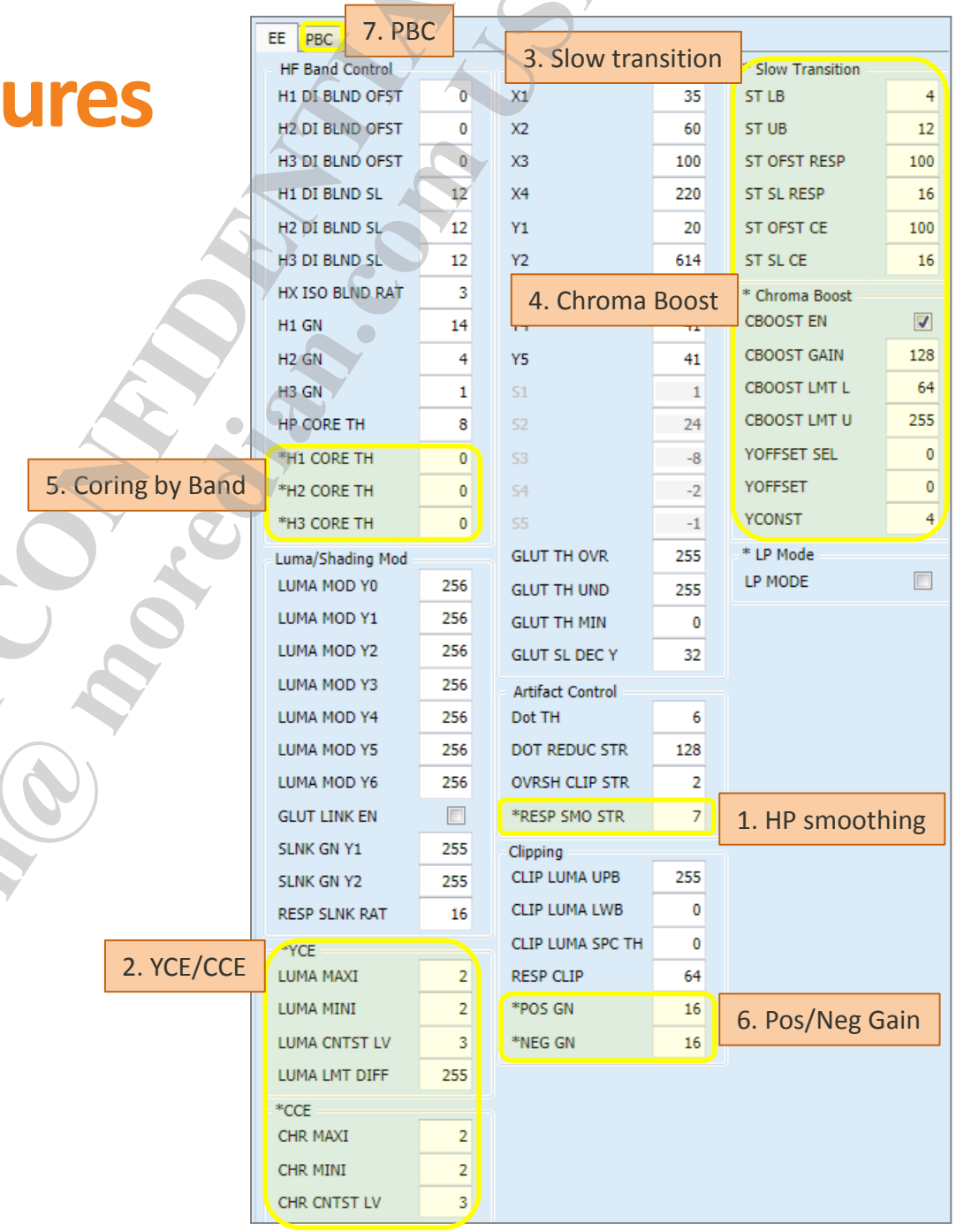
P40 EE New Features

Items
1. HP smoothing
2. YCE/CCE
3. Slow transition
4. Chroma Boost
5. Coring by Band
6. Pos/Neg Gain
7. PBC



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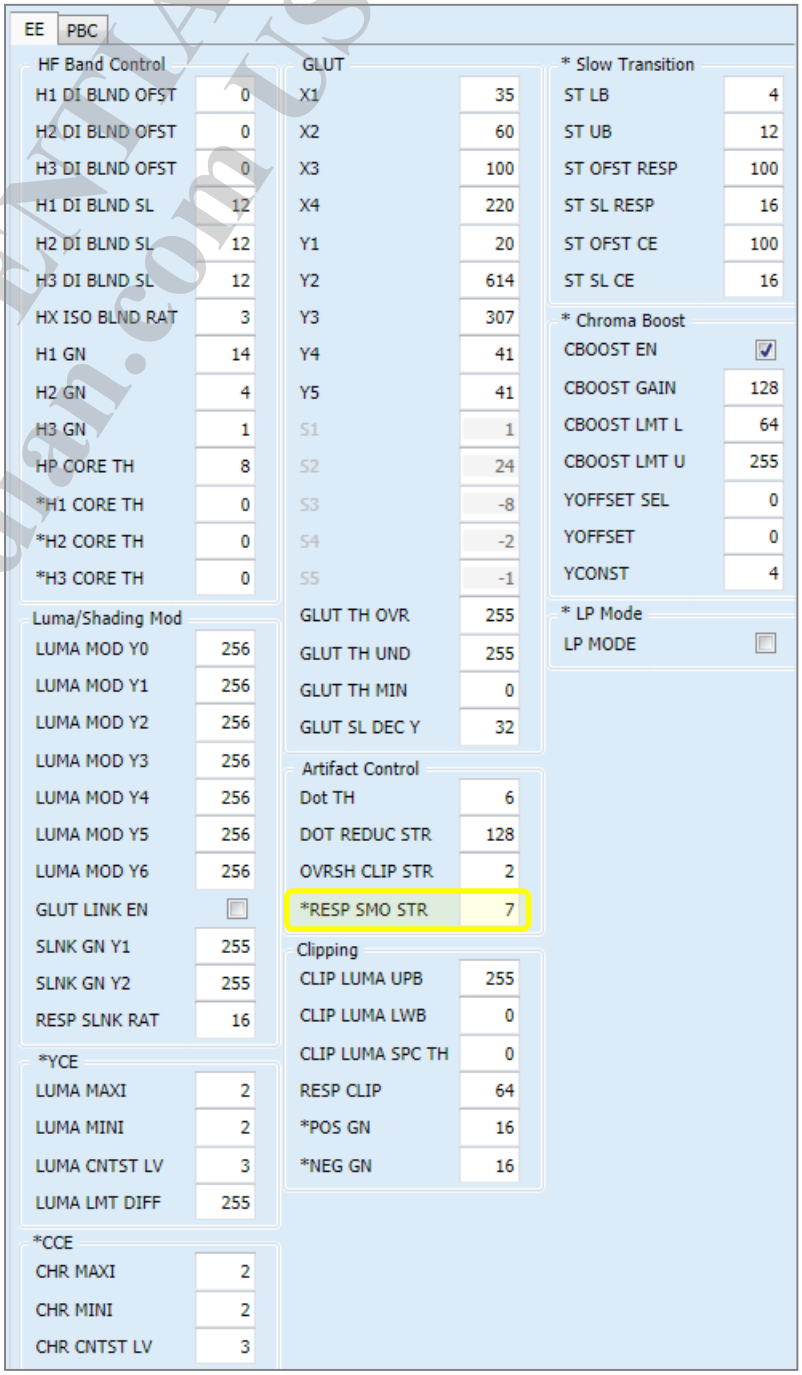
1. HP Smoothing

- Apply an smoothing filter on the HP gain map
- Smooth the Overshoot/Undershoot transition
- Higher value might cause EE strength loss



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※ Default

EE OFF | SMO_STR = 0 | SMO_STR = 4 | SMO_STR = 7

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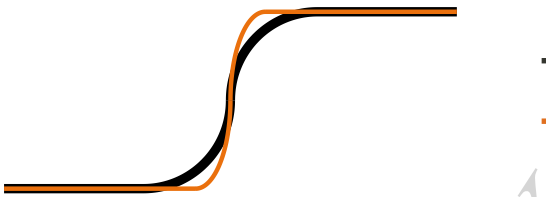
2. YCE/CCE

- Speed up edge transition speed by drawing pixels close to local max/min ones.



- No overshoot/undershoot introduced

- Strong YCE/CCE might cause jaggy-edge or oil-painting side-effects

EE | PBC

HF Band Control	
H1 DI BLND OFST	0
H2 DI BLND OFST	0
H3 DI BLND OFST	0
H1 DI BLND SL	12
H2 DI BLND SL	12
H3 DI BLND SL	12
HX ISO BLND RAT	3
H1 GN	14
H2 GN	4
H3 GN	1
HP CORE TH	8
*H1 CORE TH	0
*H2 CORE TH	0
*H3 CORE TH	0

Luma/Shading Mod	
LUMA MOD Y0	256
LUMA MOD Y1	256
LUMA MOD Y2	256
LUMA MOD Y3	256
LUMA MOD Y4	256
LUMA MOD Y5	256
LUMA MOD Y6	256
GLUT LINK EN	☐
SLNK GN Y1	255
SLNK GN Y2	255
RESP SLNK RAT	16

*YCE	
LUMA MAXI	2
LUMA MINI	2
LUMA CNTST LV	4
LUMA LMT DIFF	255

*CCE	
CHR MAXI	2
CHR MINI	2
CHR CNTST LV	4

GLUT	
X1	35
X2	60
X3	100
X4	220
Y1	20
Y2	614
Y3	307
Y4	41
Y5	41
S1	1
S2	24
S3	-8
S4	-2
S5	-1
GLUT TH OVR	255
GLUT TH UND	255
GLUT TH MIN	0
GLUT SL DEC Y	32

Artifact Control	
Dot TH	6
DOT REDUC STR	128
OVRSH CLIP STR	2
*RESP SMO STR	7

Clipping	
CLIP LUMA UPB	255
CLIP LUMA LWB	0
CLIP LUMA SPC TH	0
RESP CLIP	64
*POS GN	16
*NEG GN	16

* Slow Transition	
ST LB	4
ST UB	12
ST OFST RESP	100
ST SL RESP	16
ST OFST CE	100
ST SL CE	16

* Chroma Boost	
CBOOST EN	☑
CBOOST GAIN	128
CBOOST LMT L	64
CBOOST LMT U	255
YOFFSET SEL	0
YOFFSET	0
YCONST	4

* LP Mode	
LP MODE	☐

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EE OFF

HP Only

YCE/CCE Only

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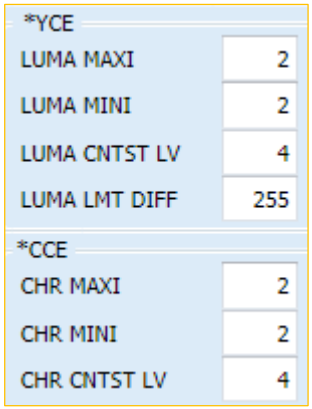
YCE/CCE Registers



Reg name	Range	Description	※Default
LUMA_MAXI	0~7	i-th max. value for YCE	2
LUMA_MINI	0~7	i-th min. value for YCE	2
LUMA_CNTST_LV	0~7	YCE Strength	4
LUMA_LMT_DIFF	0~255	Max luma changing limit(8-bit)	255
CHR_MAXI	0~3	i-th max. value for CCE	2
CHR_MINI	0~3	i-th min. value for CCE	2
CHR_CNTST_LV	0~7	CCE Strength	4

*Avoid aggressive MAXI/MINI on noisy image.

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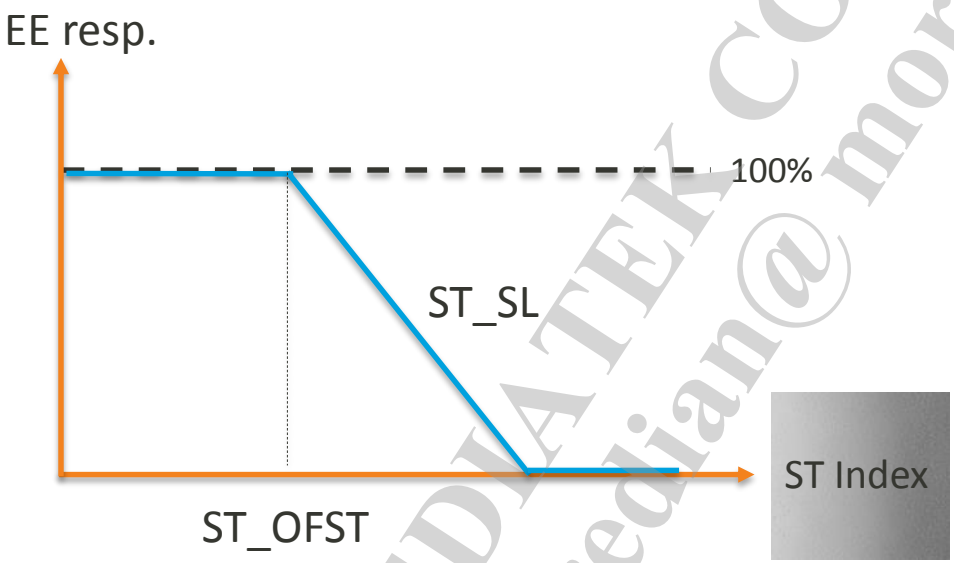
3. Slow Transition

- Avoid applying EE in gradient region for preventing **contour** artifact.



EE | PBC

HF Band Control	
H1 DI BLND OFST	0
H2 DI BLND OFST	0
H3 DI BLND OFST	0
H1 DI BLND SL	12
H2 DI BLND SL	12
H3 DI BLND SL	12
HX ISO BLND RAT	3
H1 GN	14
H2 GN	4
H3 GN	1
HP CORE TH	8
*H1 CORE TH	0
*H2 CORE TH	0
*H3 CORE TH	0

Luma/Shading Mod	
LUMA MOD Y0	256
LUMA MOD Y1	256
LUMA MOD Y2	256
LUMA MOD Y3	256
LUMA MOD Y4	256
LUMA MOD Y5	256
LUMA MOD Y6	256
GLUT LINK EN	☐
SLNK GN Y1	255
SLNK GN Y2	255
RESP SLNK RAT	16

*YCE	
LUMA MAXI	2
LUMA MINI	2
LUMA CNTST LV	3
LUMA LMT DIFF	255

*CCE	
CHR MAXI	2
CHR MINI	2
CHR CNTST LV	3

GLUT	
X1	35
X2	60
X3	100
X4	220
Y1	20
Y2	614
Y3	307
Y4	41
Y5	41
S1	1
S2	24
S3	-8
S4	-2
S5	-1
GLUT TH OVR	255
GLUT TH UND	255
GLUT TH MIN	0
GLUT SL DEC Y	32

Artifact Control	
Dot TH	6
DOT REDUC STR	128
OVRSH CLIP STR	2
*RESP SMO STR	7

Clipping	
CLIP LUMA UPB	255
CLIP LUMA LWB	0
CLIP LUMA SPC TH	0
RESP CLIP	64
*POS GN	16
*NEG GN	16

Slow Transition	
ST LB	4
ST UB	12
ST OFST RESP	100
ST SL RESP	16
ST OFST CE	100
ST SL CE	16

* Chroma Boost	
CBOOST EN	☑
CBOOST GAIN	128
CBOOST LMT L	64
CBOOST LMT U	255
YOFFSET SEL	0
YOFFSET	0
YCONST	4

* LP Mode	
LP MODE	☐

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Slow transition Registers

Reg name	Range	Description	※Suggest
ST_LB	0~255	Slow transition index lower bound	1~3
ST_UB	0~255	Slow transition index upper bound	9~12
ST_OFST_RESP	0~255	HP response slow trans. offset	96~128
ST_SL_RESP	0~255	HP response slow trans. slope	2~4
ST_OFST_CE	0~255	YCE/CCE slow trans. offset	96~128
ST_SL_CE	0~255	YCE/CCE slow trans. slope	2~4

*set ITUNE_SEEE_DEBUG_STAT = 1 to see slow trans. Ink image

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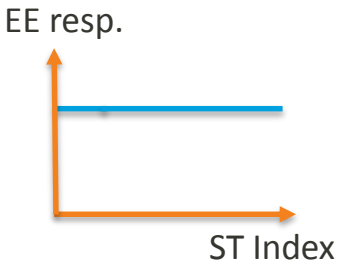
ST_SL_RESP = ST_SL_CE = 0 (ST Disable)



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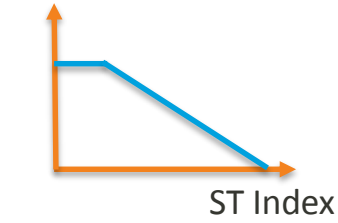
ST_SL_RESP = ST_SL_CE = 4



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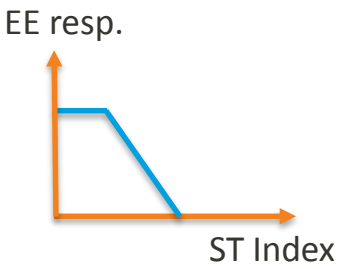
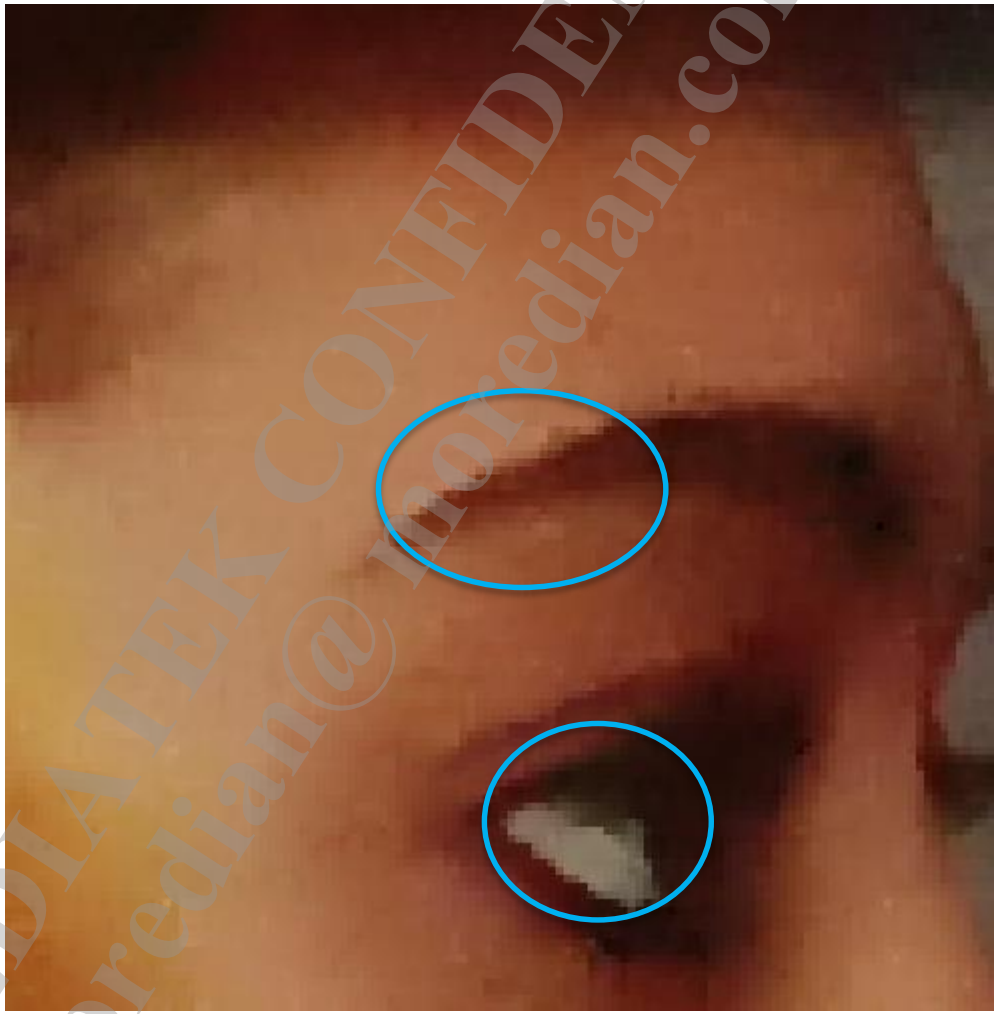
ST_SL_RESP = ST_SL_CE = 16





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4. Chroma Boost

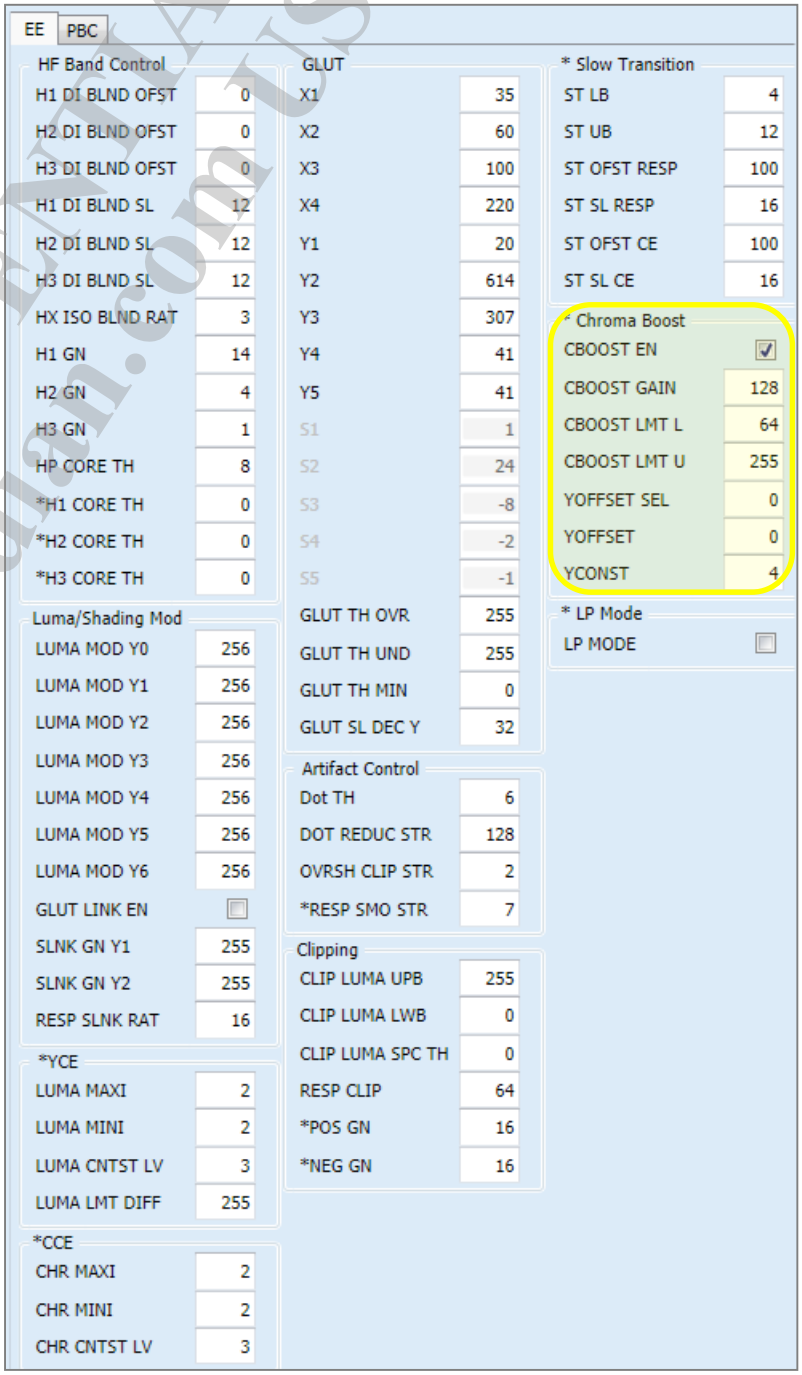
- Compensate UV channel based on Y

$$Ratio = (Y_{Out} - Y_{ofst}) / (Y_{In} - Y_{ofst})$$

$$Cb_{Out} = Cb_{In} \cdot Ratio$$

$$Cr_{Out} = Cr_{In} \cdot Ratio$$

$$Y_{ofst} = \min(\ Y_{In} >> \text{YOFFSET\_SEL},\ \text{YOFFSET})$$



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Chroma Boost Registers

Reg name	Range	Description	※Default
CBOOST_EN	0~1	Chroma boost enable	0
CBOOST_GAIN	0~255	Boost gain(1x=128)	128
CBOOST_LMT_L	0~255	Boost ratio minimum (1x=128)	64
CBOOST_LMT_U	0~255	Boost ratio maximum (1x=128)	255
CBOOST_YOFFSET_SEL	0~3	Boost Ratio Parameter	0
CBOOST_YOFFSET	0~255	Boost Ratio Parameter	0
CBOOST_YCONST	1~255	Low Y Protection	4

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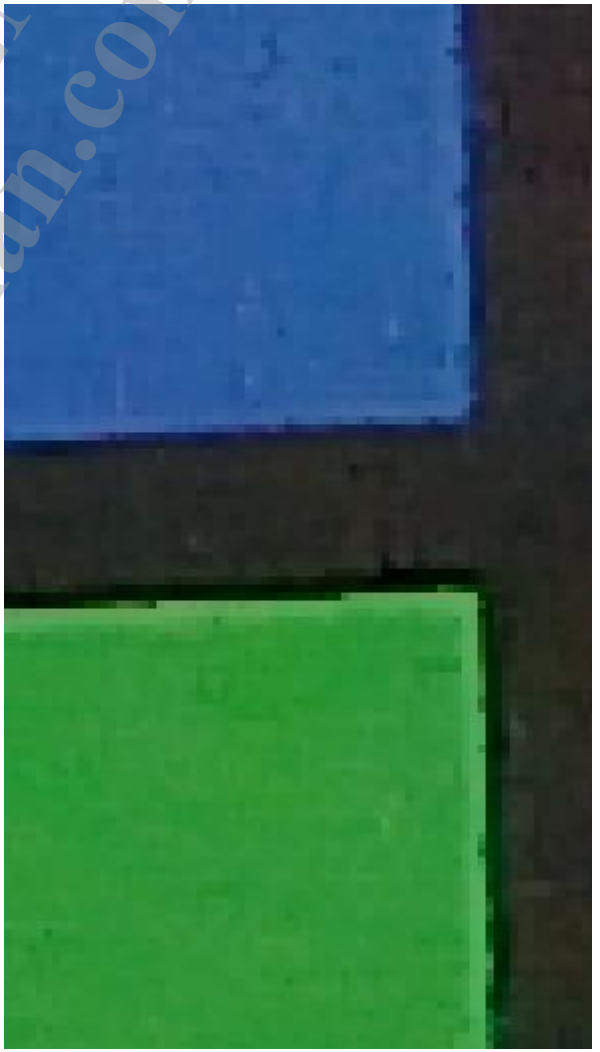
CBOOST_GAIN = 0 (OFF)



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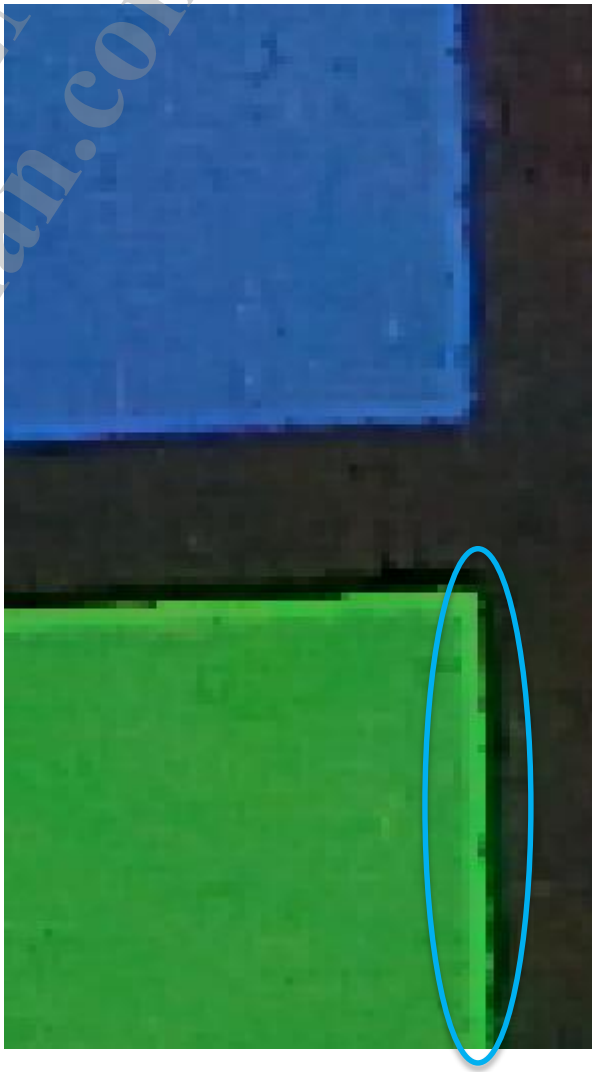
CBOOST_GAIN = 128 (1x)



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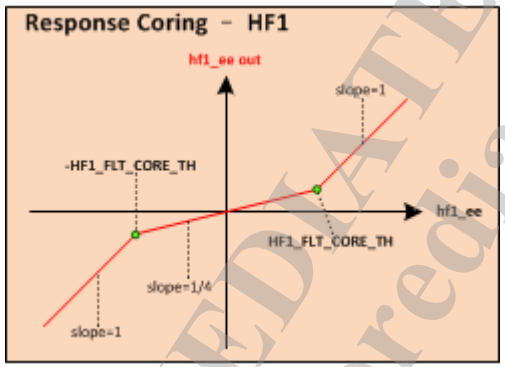
5. Coring by Band

- Core noise in flat region by different freq.

Reg name	Range	Description	※Default
H1_FLT_CORE_TH	0~255	H1 Coring threshold	0
H2_FLT_CORE_TH	0~255	H2 Coring threshold	0
H3_FLT_CORE_TH	0~255	H3 Coring threshold	0



EE | PBC

HF Band Control	
H1 DI BLND OFST	0
H2 DI BLND OFST	0
H3 DI BLND OFST	0
H1 DI BLND SL	12
H2 DI BLND SL	12
H3 DI BLND SL	12
HX ISO BLND RAT	3
H1 GN	14
H2 GN	4
H3 GN	1
HP CORE TH	8
*H1 CORE TH	0
*H2 CORE TH	0
*H3 CORE TH	0

Luma/Shading Mod	
LUMA MOD Y0	256
LUMA MOD Y1	256
LUMA MOD Y2	256
LUMA MOD Y3	256
LUMA MOD Y4	256
LUMA MOD Y5	256
LUMA MOD Y6	256
GLUT LINK EN	☐
SLNK GN Y1	255
SLNK GN Y2	255
RESP SLNK RAT	16

*YCE	
LUMA MAXI	2
LUMA MINI	2
LUMA CNTST LV	3
LUMA LMT DIFF	255

*CCE	
CHR MAXI	2
CHR MINI	2
CHR CNTST LV	3

GLUT	
X1	35
X2	60
X3	100
X4	220
Y1	20
Y2	614
Y3	307
Y4	41
Y5	41
S1	1
S2	24
S3	-8
S4	-2
S5	-1
GLUT TH OVR	255
GLUT TH UND	255
GLUT TH MIN	0
GLUT SL DEC Y	32

Artifact Control	
Dot TH	6
DOT REDUC STR	128
OVRSH CLIP STR	2
*RESP SMO STR	7

Clipping	
CLIP LUMA UPB	255
CLIP LUMA LWB	0
CLIP LUMA SPC TH	0
RESP CLIP	64
*POS GN	16
*NEG GN	16

* Slow Transition	
ST LB	4
ST UB	12
ST OFST RESP	100
ST SL RESP	16
ST OFST CE	100
ST SL CE	16

* Chroma Boost	
CBOOST EN	☑
CBOOST GAIN	128
CBOOST LMT L	64
CBOOST LMT U	255
YOFFSET SEL	0
YOFFSET	0
YCONST	4

* LP Mode	
LP MODE	☐

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6. Pos/Neg Gain

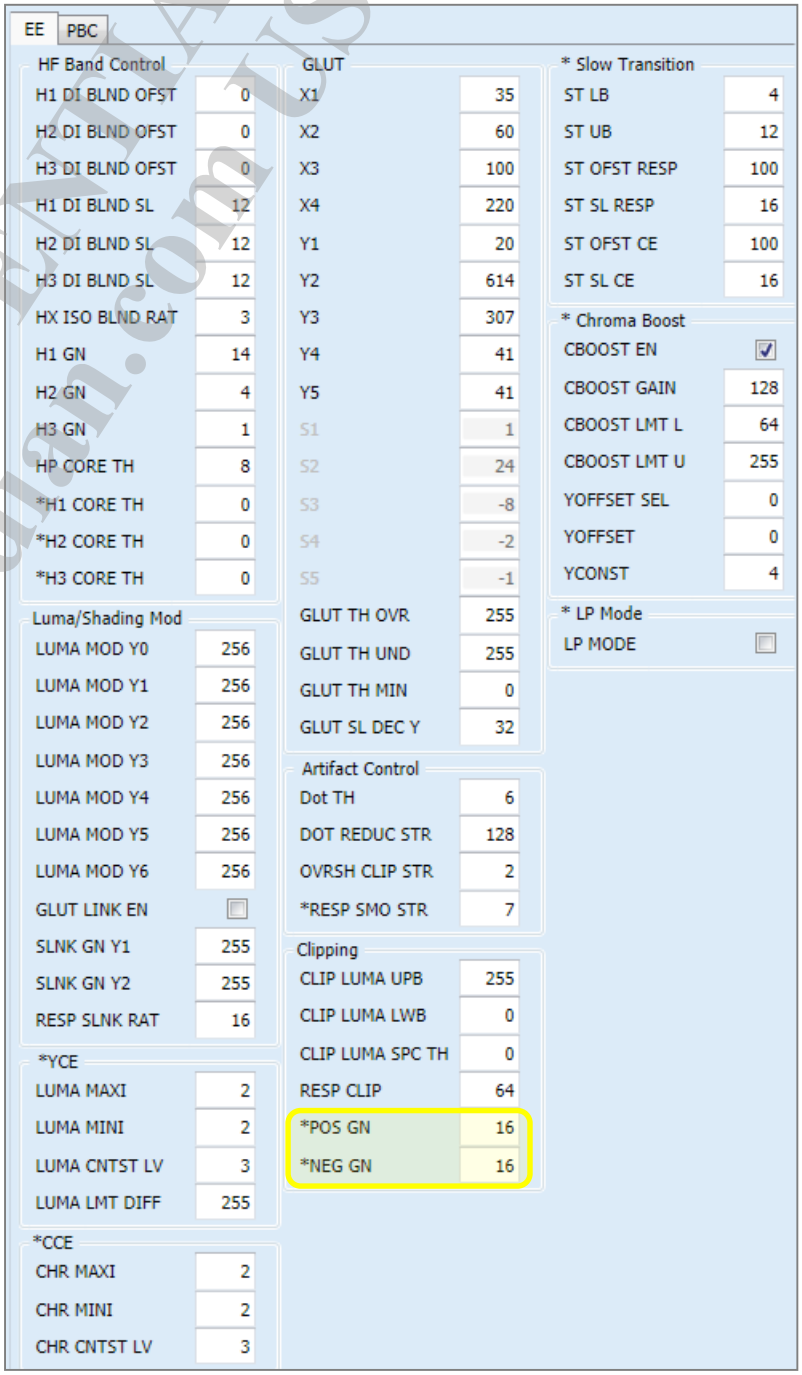
- To suppress over/under-shoot separately

Reg name	Range	Description	※Default
MASTER_GN_POS	0~255	Pos. HP resp. gain (16 = 1x)	16
MASTER_GN_NEG	0~255	Neg. HP resp. gain (16 = 1x)	16

- Similar to

*HNEG GN	16
*HPOS GN	16

in UDM



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POS GN = 16
NRG GN = 16

MEDIATEK CONFIDENTIAL B
moredian@ MediaTek USE

POS GN = 16
NRG GN = 0

MEDIATEK CONFIDENTIAL B

POS GN = 0
NRG GN = 16

MEDIATEK CONFIDENTIAL B
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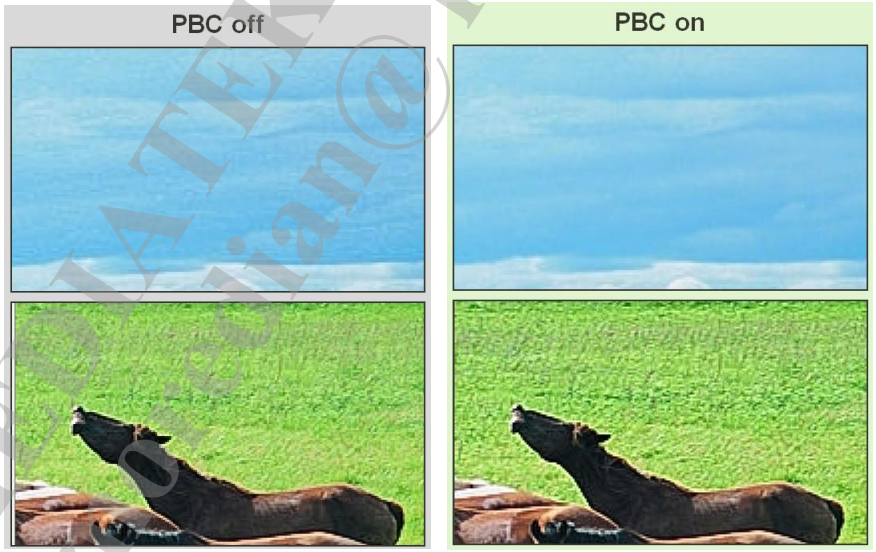
7. PBC
(Peaking By Color)

- Color dependent EE/blurring

- 3 color region supported (PBC1, PBC2, PBC3)

EE | PBC | SE2 | SE

* PBC1		* PBC2		* PBC3	
PBC EN	☐	PBC2 EN	☑	PBC3 EN	☑
PBC1 EN	☑	PBC2 RSLOPE 1	32	PBC3 RSLOPE 1	17
PBC1 RSLOPE 1	39	PBC2 RSLOPE	43	PBC3 RSLOPE	32
PBC1 RSLOPE	85	PBC2 RADIUS R	40	PBC3 RADIUS R	42
PBC1 RADIUS R	42	PBC2 RADIUS C	48	PBC3 RADIUS C	60
PBC1 RADIUS C	48	PBC2 THETA C	88	PBC3 THETA C	224
PBC1 THETA C	149	PBC2 THETA R	24	PBC3 THETA R	32
PBC1 THETA R	24	PBC2 TSLOPE	43	PBC3 TSLOPE	64
PBC1 TSLOPE	85	PBC2 GAIN	24	PBC3 GAIN	24
PBC1 GAIN	52	PBC2 CONF GAIN	4	PBC3 CONF GAIN	1
PBC1 CONF GAIN	1	PBC2 EDGE THR	32	PBC3 EDGE THR	8
PBC1 EDGE THR	63	PBC2 EDGE SLOPE	24	PBC3 EDGE SLOPE	24
PBC1 EDGE SLOPE	8	PBC2 EDGE EN	☑	PBC3 EDGE EN	☑
PBC1 EDGE EN	☐	PBC2 LPF EN	☑	PBC3 LPF EN	☑
PBC1 LPF EN	☐	PBC2 LPF GAIN	12	PBC3 LPF GAIN	8
PBC1 LPF GAIN	16				



(Lower EE in blue region)

(Higher EE in green region)

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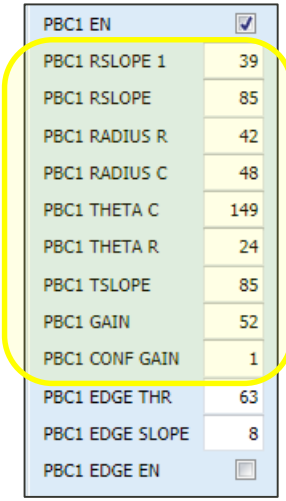
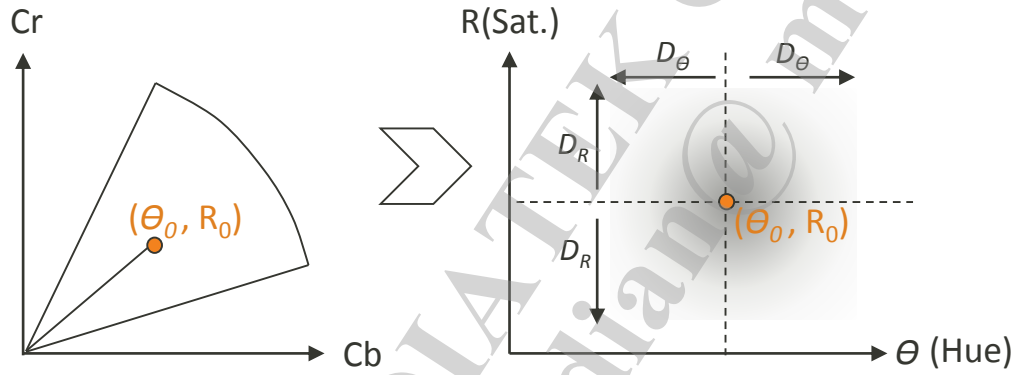
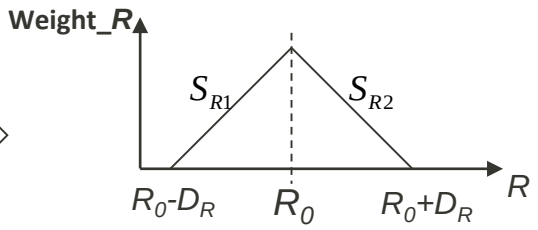
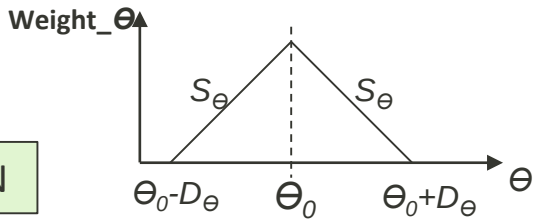
7.1 Color Selection Registers

Reg name	Range	Description	
PBC1_RADIUS_C	0~255	Saturation center (R_0)	Sat.
PBC1_RADIUS_R	0~63	Saturation radius (D_R)	
PBC1_RSLOPE	0~1023	Saturation left slope (S_{R1})	
PBC1_RSLOPE_1	0~1023	Saturation right slope1 (S_{R2})	
PBC1_THETA_C	0~255	Hue center (Θ_0)	Hue
PBC1_THETA_R	0~63	Hue radius (D_Θ)	
PBC1_TSLOPE	0~1023	Hue slope (S_Θ)	
PBC1_CONF_GAIN	0~15	Confidence gain	









Confidence_D = Weight_Θ * Weight_R * CONF_GAIN

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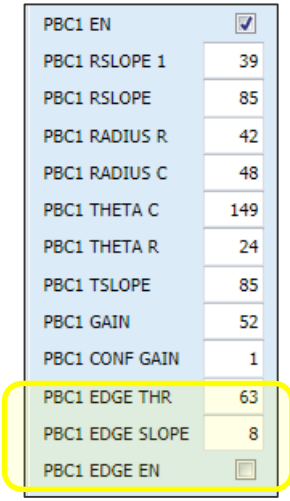
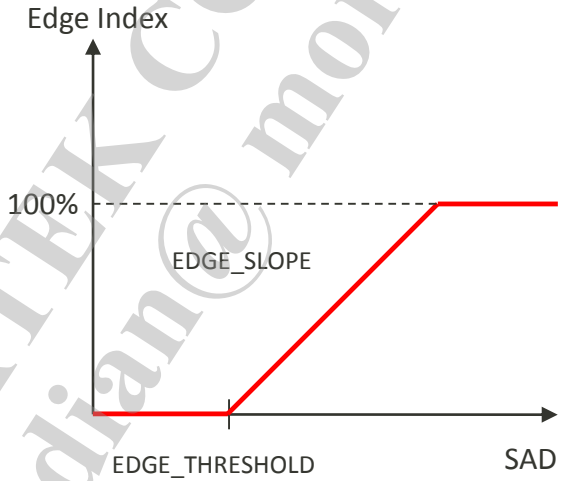
7.2 Edge Preserve Registers

Reg name	Range	Description	※Default
PBC1_EDGE_EN	0~1	Enable Edge Protection	0
PBC1_EDGE_THR	0~63	Edge Protection threshold(u.6.0)	63
PBC1_EDGE_SLOPE	0~63	Edge Protection slope(u.0.6)	8



- Decrease color confidence in edge area
- Prevent edge being over enhanced



Confidence_E = Confidence_D * (100% - Edge_Index)

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