

CONFIDENTIAL B

MEDIATEK

P40 DMEE

Introduction & Usage



Outline

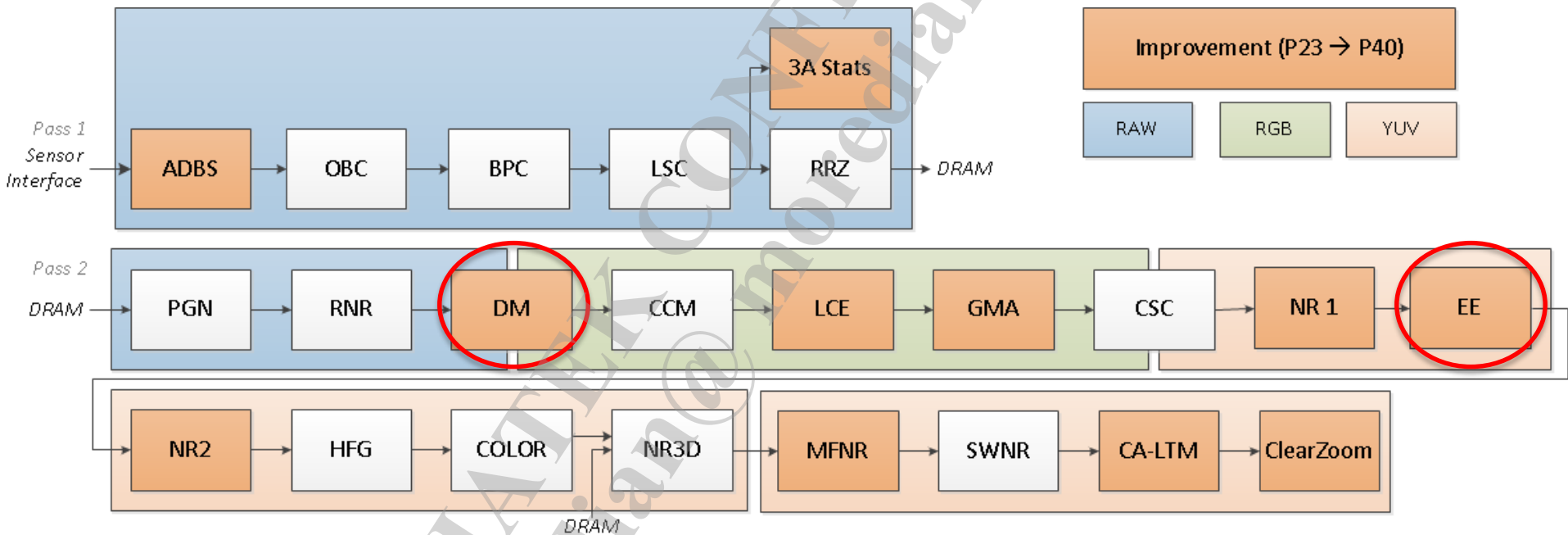
■ DM Improvement

- 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

P40 Block Diagram



Outline

■ DM Improvement

- DM-P1 Upgrade
- DM-P1&DM-P2 Blending
- Pos/Neg EE Response
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■ EE Improvement

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- YCE/CCE
- Slow transition
- Chroma Boost
- Coring by Band
- Pos/Neg Gain
- PBC

P23 DM → P40 DM

UDM reg1
☐ ITUNE UDM
☐ UDM BYP

Crosstalk

8	XTK RAT
32	XTK OFST
5	XTK SL
255	DS THB
5	DS SLB

HF/EE Strength

11	HT GN1	7	HA STR
11	HT GN2	4	H1 GN
11	HD GN1	4	H2 GN
11	HD GN2	4	H3 GN
		8	HI RAT

EE Suppress

0	CORE TH1
0	CORE TH2
255	OV TH
0	UN TH
0	CLIP TH

NR strength/activity LUT

	N0	N1	N2
STR	10	6	2
OFST	25	25	25
10	NSL	0	NGR

HF activity LUT

	H1	H2	H3
LWB	8	8	8
UPB	8	8	8
8	HSL	9	HSLR

NR Strength

EE LUT

Luma Blending

255	L0 OFST
6	L0 SL
0	L1 OFST
6	L1 SL
3	L2 OFST
6	L2 SL

Luma/SL modulation

511	LM Y0
381	LM Y1
304	LM Y2
216	LM Y3
137	LM Y4
79	LM Y5
15	LR RAT
208	SL Y1
128	SL Y2
16	SL HR

RRZ ratio

0	SL RAT
0	SC RAT

Color Checker Info

Auto Luma LUT Save Act Info
 Save Grad Info Save Luma Info

HF/EE Strength

EE Suppress

NR strength/activity LUT

HF activity LUT

NR Strength

EE LUT

Luma Blending

Luma/SL Mod.

RRZ ratio

UDM Mode
☐ MN MODE
☐ BYP

***H/V Weight**

<input checked="" type="checkbox"/>	CD KNL
10	CDG RAT
0	CDG OFST
10	CDG SL

***Dot Correction**

5	INT LTH
3	INT CDTH

***P1&P2 Blending**

0	P1 LWB
255	P1 UPB
0	P1 BLD

***RGB CLIP**

<input type="checkbox"/>	RGB CLIP
--------------------------	----------

HF Gain

11	HT GN1
11	HT GN2
11	HD GN1
11	HD GN2
11	*HD GN3
16	*HFRB GN

HF STR

7	HA STR
4	H1 GN
4	H2 GN
4	H3 GN
8	HI RAT

HF ACT LUT

8	H1 LWB
8	H2 LWB
8	H3 LWB
8	H1 UPB
8	H2 UPB
8	H3 UPB
9	HSLR
8	HSL

EE Suppress

0	CORE TH1
0	CORE TH2
255	OV TH
0	UN TH
0	CLIP TH

***HNEG GN**

16	*HNEG GN
----	----------

***HPOS GN**

16	*HPOS GN
----	----------

NR STR

10	N0 STR
6	N1 STR
2	N2 STR

NR ACT LUT

25	N0 OFST
25	N1 OFST
15	N2 OFST
10	NSL
0	NGR

Shading Link

<input checked="" type="checkbox"/>	SL EN
208	SL Y1
128	SL Y2
16	SL HR

CrossTalk

8	XTK RAT
32	XTK OFST
5	XTK SL

RRZ Ratio

<input type="checkbox"/>	FL MODE
0	SL RAT
0	SC RAT

LR RAT

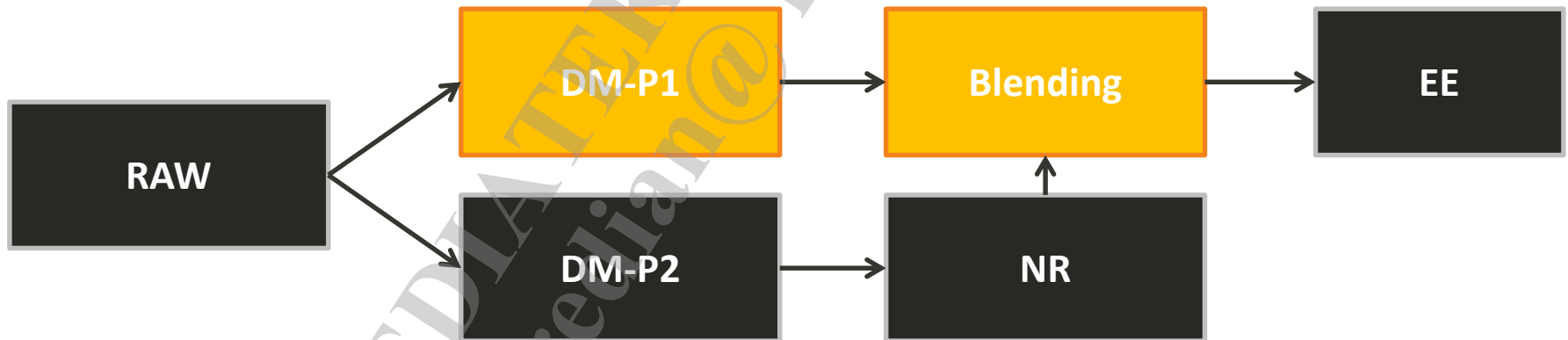
15	LR RAT
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DM Flow Change

P23



P40



DM-P1/P2 Difference



DM-P1

More detail/noise



DM-P2

Less detail/noise

P40 DM New Features

Items

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

1. DM-P1 Upgrade

2. DM-P1 & DM-P2 Blending

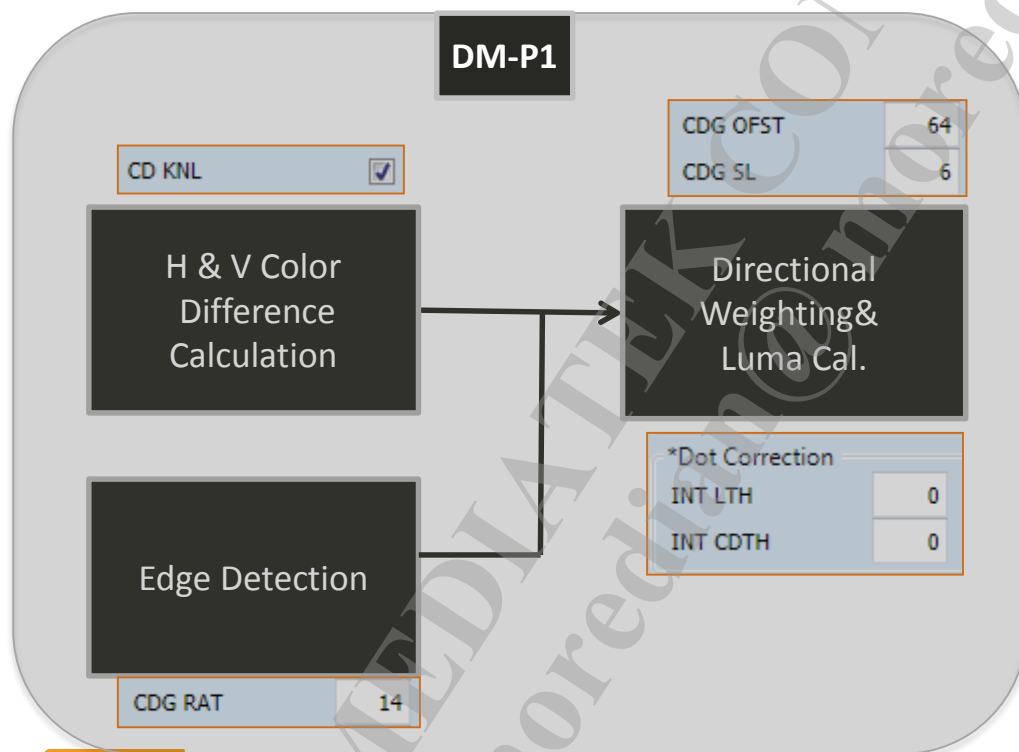
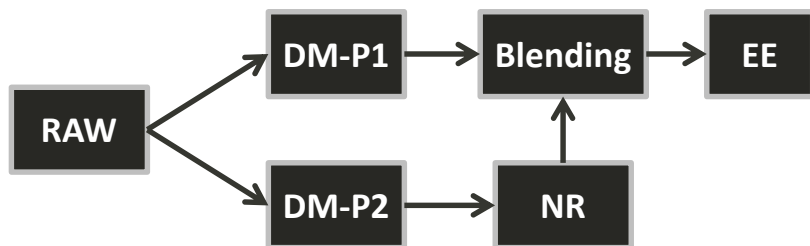
4. Clipping Recovery

For Mono Sensor

UDM Mode		HF GN1		CrossTalk	
MN MODE	<input type="checkbox"/>	HT GN2	11	XTK RAT	8
BYP	<input type="checkbox"/>	HD GN1	11	XTK OFST	32
*H/V Weight		HD GN2	11	XTK SL	5
CD KNL	<input checked="" type="checkbox"/>	*HD GN3	11	RRZ Ratio	
CDG RAT	10	*HFRB GN	16	FL MODE	<input type="checkbox"/>
CDG OFST	0	HF STR		SL RAT	0
CDG SL	10	HA STR	7	SC RAT	0
*Dot Correction		H1 GN	4	LR RAT	
INT LTH	5	H2 GN	4	LR RAT	15
INT CDTH	3	H3 GN	4		
*P1&P2 Blending		HI RAT	8		
P1 LWB	0	HF ACT LUT			
P1 UPB	255	H1 LWB	8		
P1 BLD	0	H2 LWB	8		
*RGB CLIP		H3 LWB	8		
RGB CLIP	<input type="checkbox"/>	H1 UPB	8		
luma blending		H2 UPB	8		
CD SLC	10	H3 UPB	8		
CD SLL	3	HSLR	9		
DN OFST	0	HSLL	8		
HL OFST	63				
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				
LM Y2	304	NR STR			
LM Y3	216	N0 STR	10		
LM Y4	137	N1 STR	6		
LM Y5	79	N2 STR	2		
Shading Link		NR ACT LUT			
SL EN	<input checked="" type="checkbox"/>	N0 OFST	25		
SL Y1	208	N1 OFST	25		
SL Y2	128	N2 OFST	15		
SL HR	16	NSL	10		
		NGR	0		

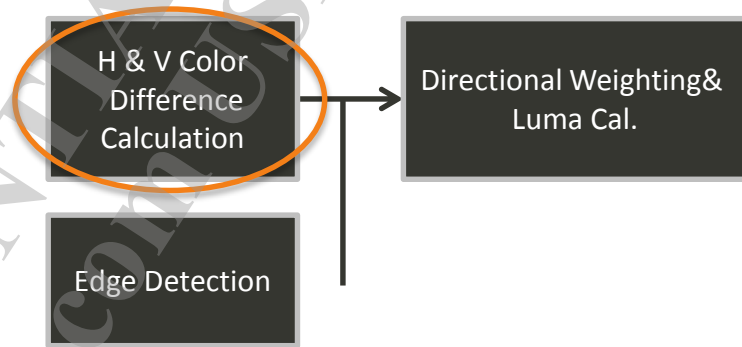
3. Pos/Neg EE Response

1. DM-P1 Upgrade



UDM Mode	<input type="checkbox"/>	HF Gain	11	CrossTalk	XTK RAT	8
MN MODE	<input type="checkbox"/>	HT GN1	11		XTK OFST	32
BYP	<input type="checkbox"/>	HT GN2	11		XTK SL	5
*H/V Weight	<input checked="" type="checkbox"/>	HD GN1	11	RRZ Ratio	FL MODE	<input type="checkbox"/>
CD KNL	<input checked="" type="checkbox"/>	HD GN2	11		SL RAT	0
CDG RAT	10	*HD GN3	11		SC RAT	0
CDG OFST	0	*HFRB GN	16		LR RAT	15
CDG SL	10	HF STR				
*Dot Correction		HA STR	7			
INT LTH	5	H1 GN	4			
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	<input type="checkbox"/>	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	<input checked="" type="checkbox"/>	N1 OFST	25			
SL Y1	208	N2 OFST	15			
SL Y2	128	NSL	10			
SL HR	16	NGR	0			

1.1 H/V Color Difference Calculation



R	G	R	G	R
G	B	G	B	G
R	G	R	G	R
G	B	G	B	G
R	G	R	G	R

raw

CD^H

R	G	R	G	R
G	B	G	B	G
R	G	R	G	R
G	B	G	B	G
R	G	R	G	R

CD^V

R	G	R	G	R
G	B	G	B	G
R	G	R	G	R
G	B	G	B	G
R	G	R	G	R



G-R

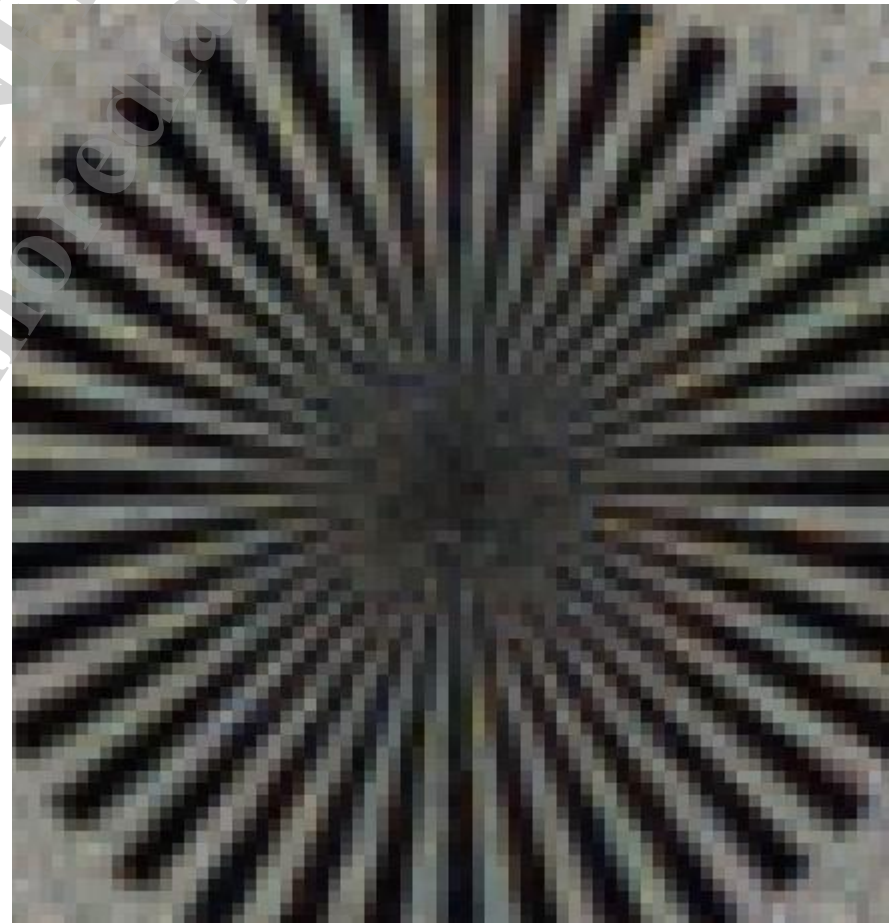


G-B

CD_KNL = 0

Show Pure DM1 Result →

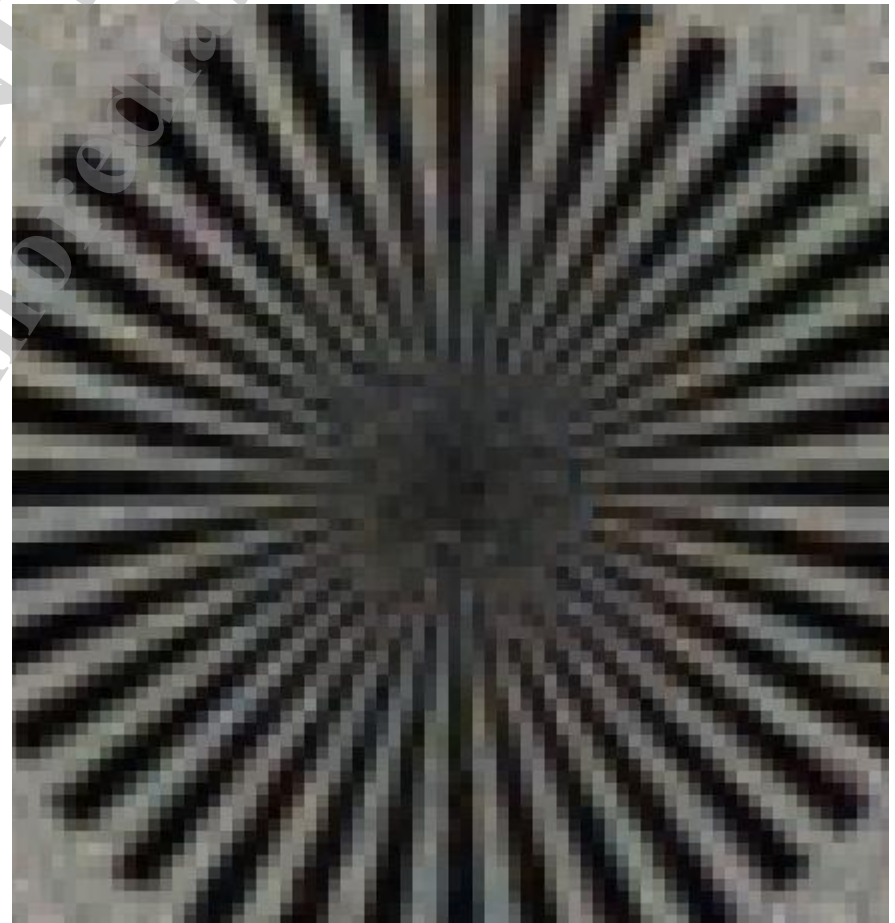
*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



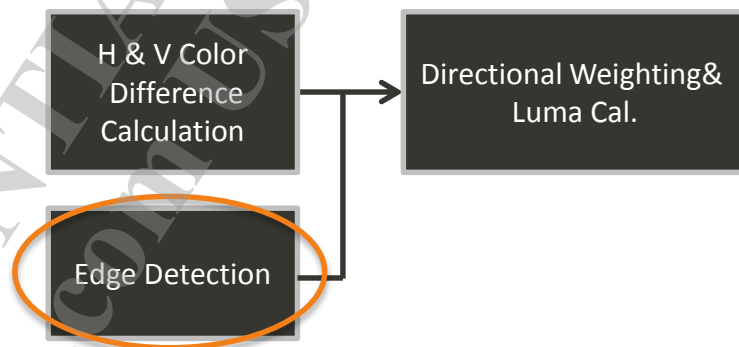
CD_KNL = 1 (✖ Default, No Need to Tune)

Show Pure DM1 Result →

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



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.

CDG_RAT = 16

CDG OFST	0
CDG SL	6

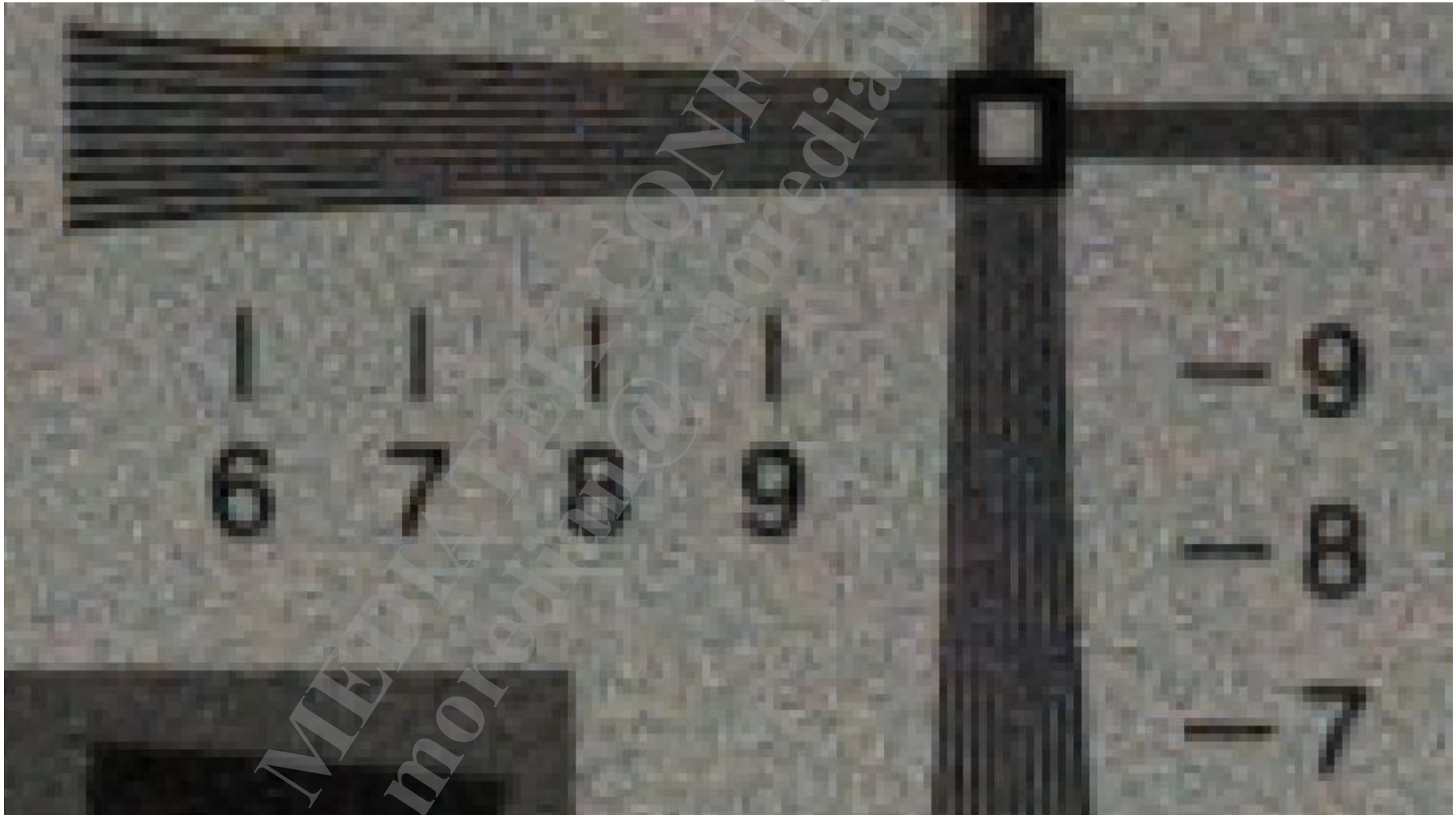
*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



CDG_RAT = 14

CDG OFST	0
CDG SL	6

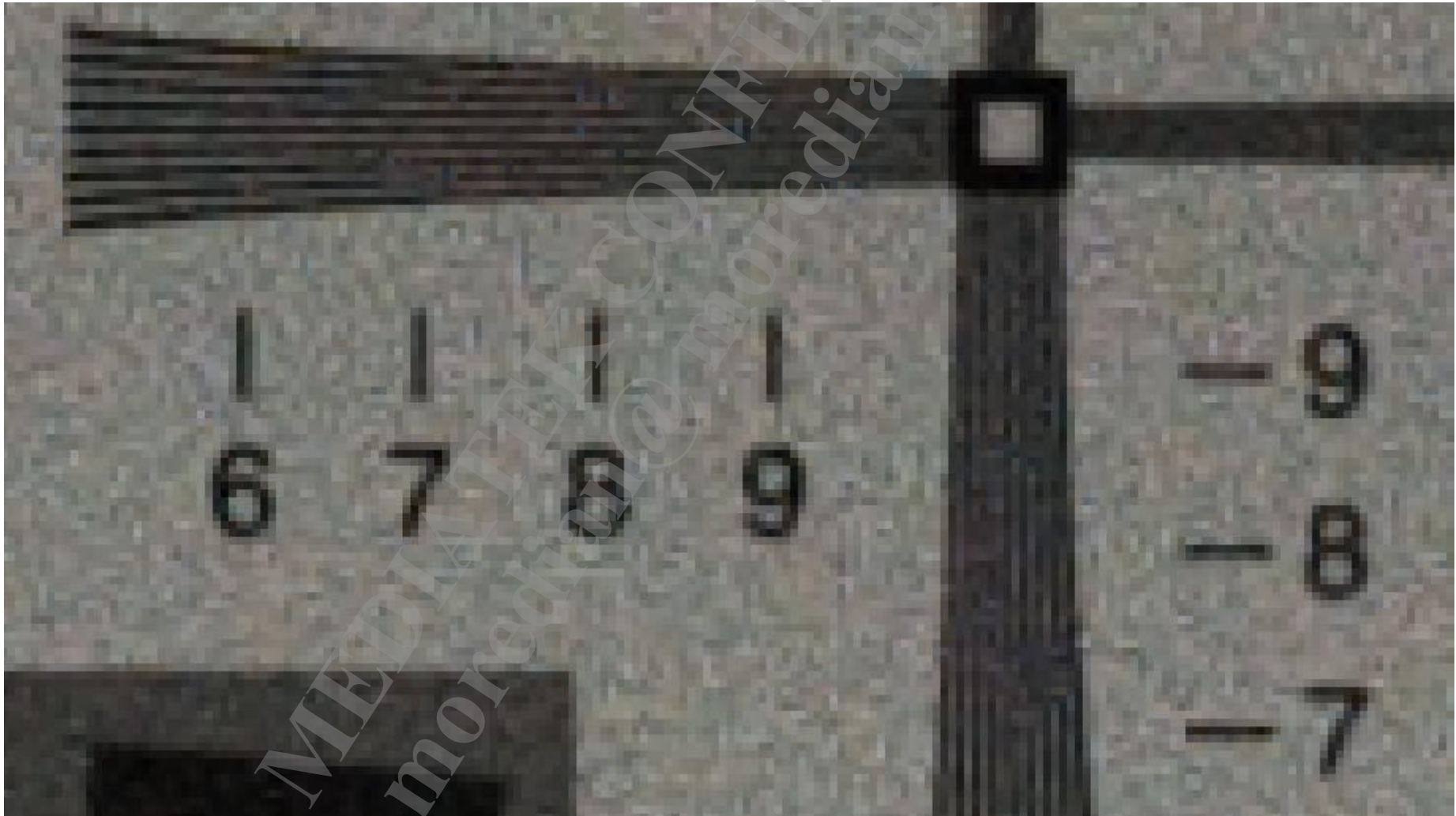
*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



CDG_RAT = 12 (✖ Preferred)

CDG OFST	0
CDG SL	6

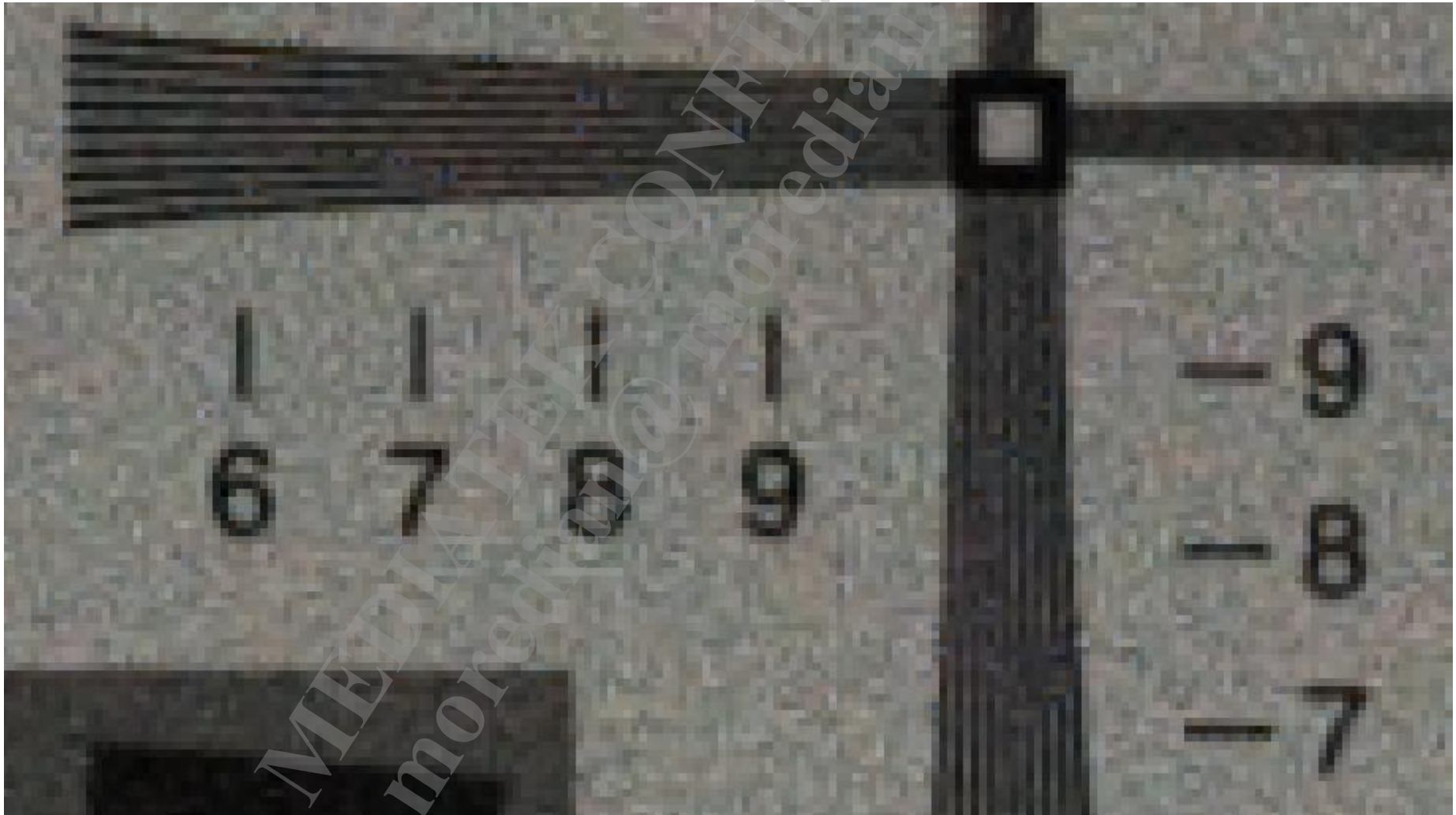
*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



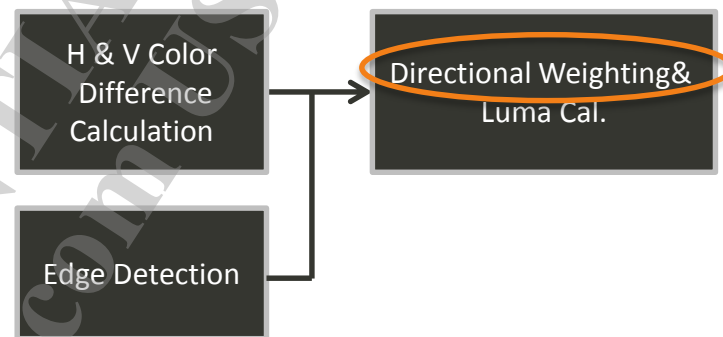
CDG_RAT = 8

CDG OFST	0
CDG SL	6

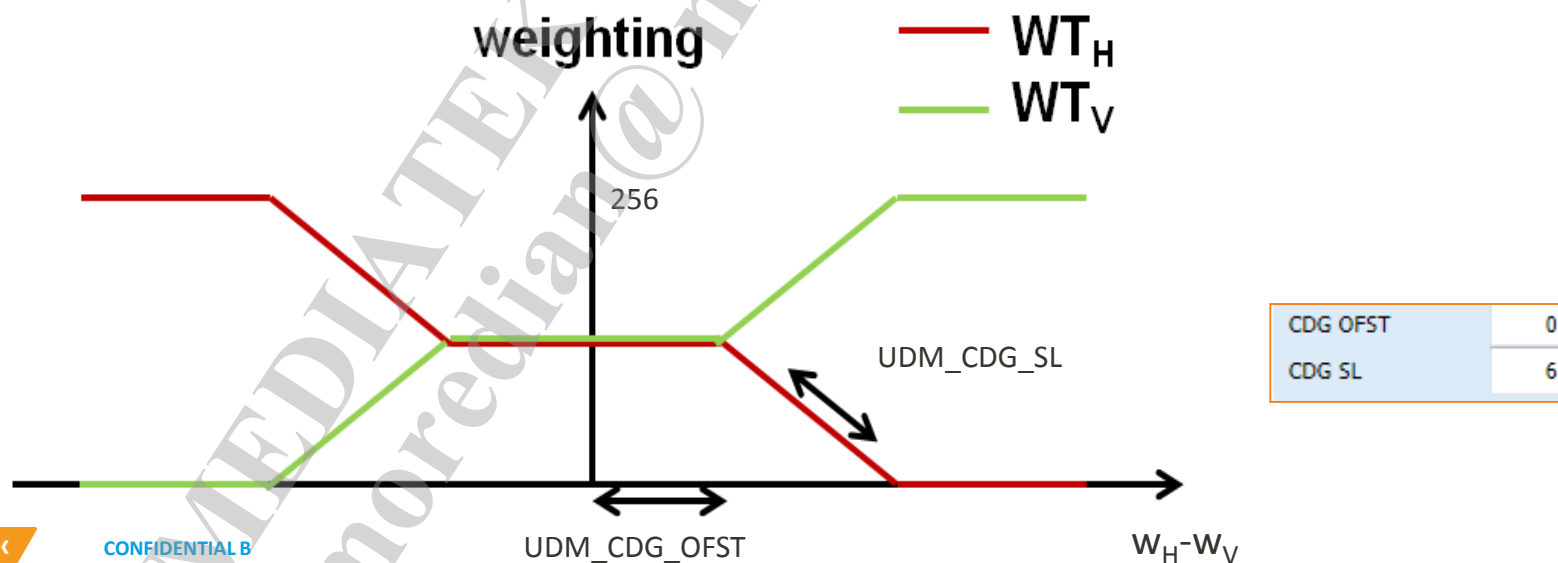
*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



1.3 Weighting CD



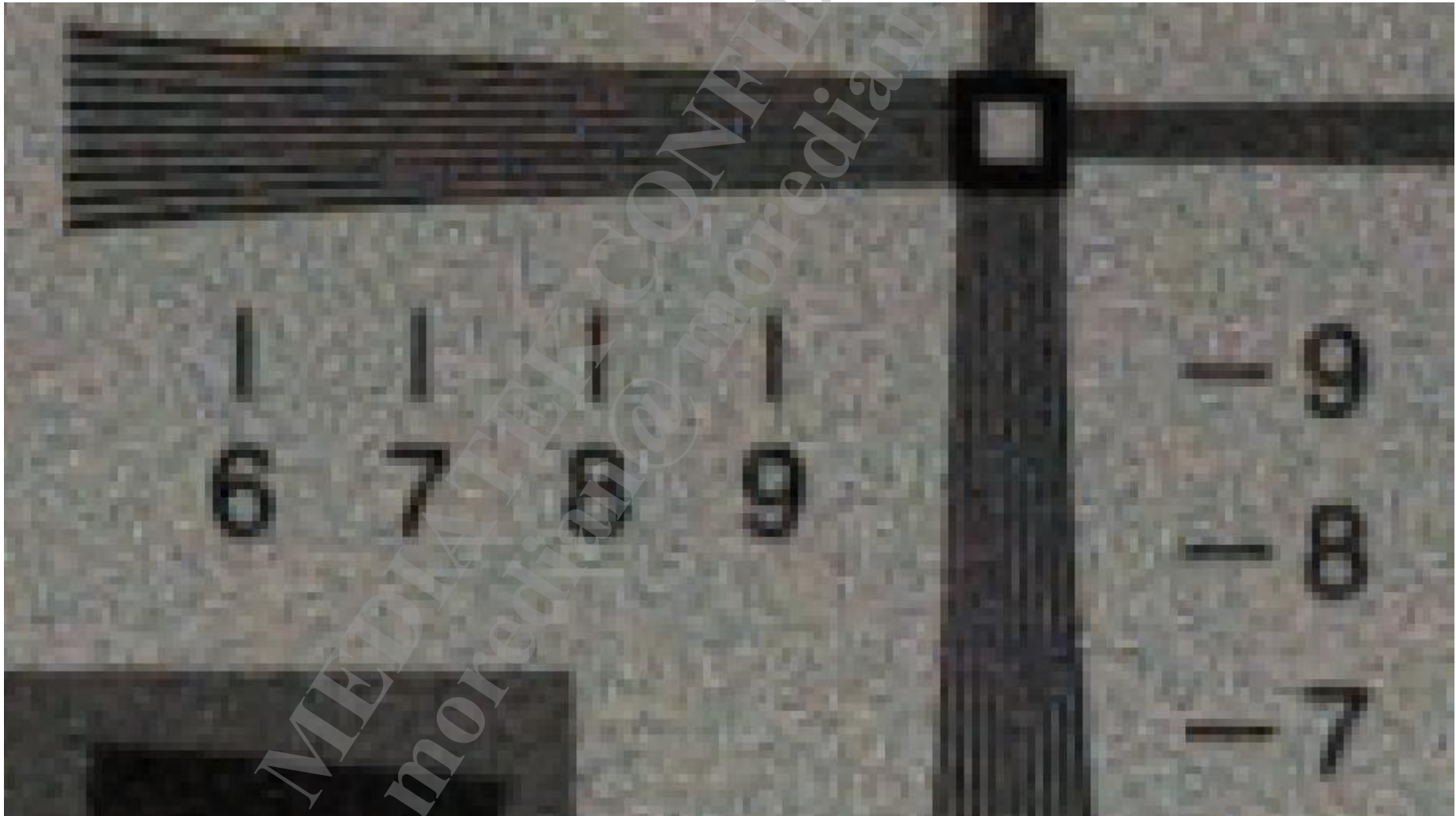
- Final Color Difference (CD) is adaptive combined by Horizontal Gradient Weighting (W_H) and Vertical Gradient Weighting (W_V)



CDG_OFST = 0 (✖ Preferred)

CDG RAT	14
CDG SL	6

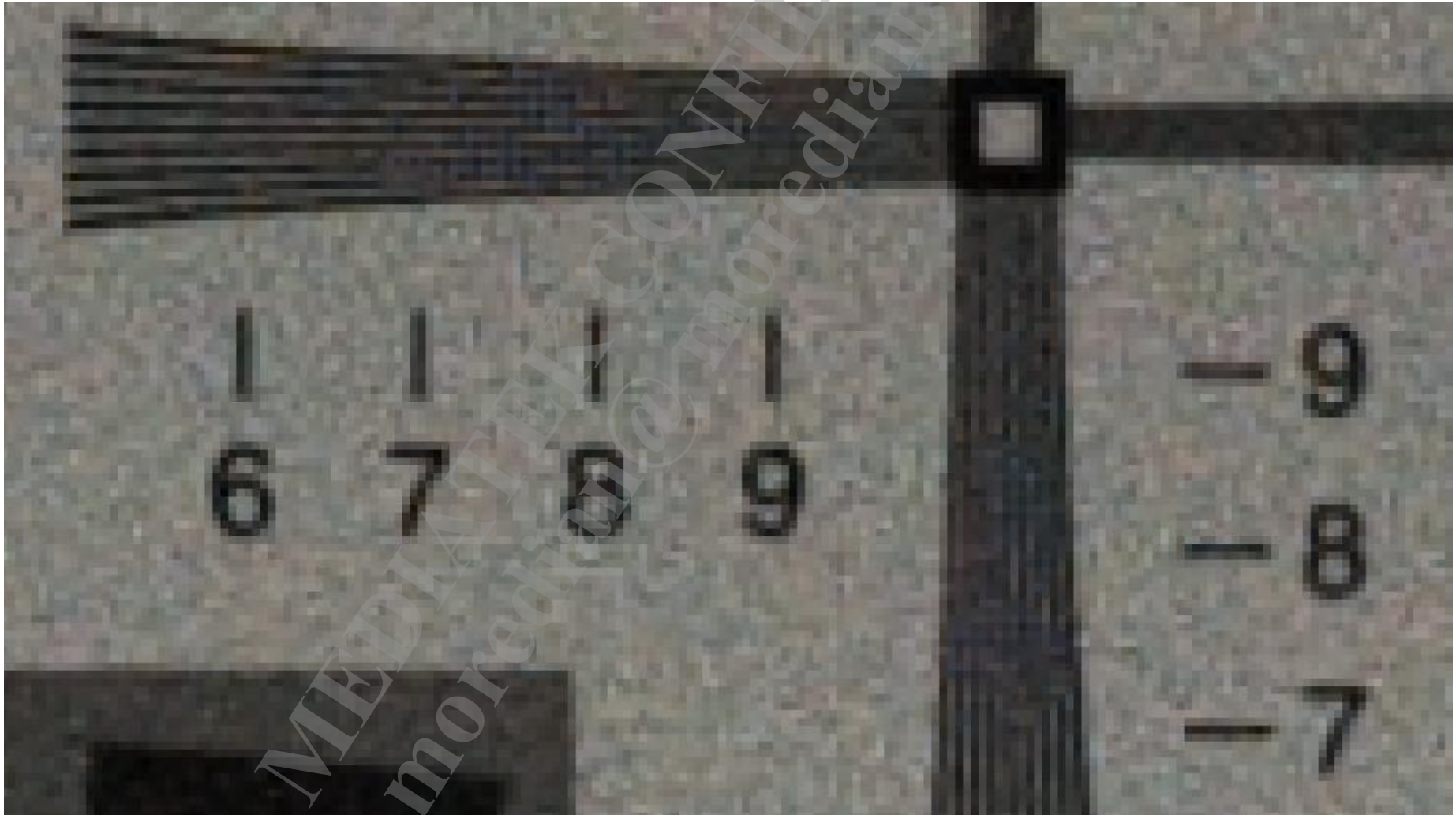
*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



CDG_OFST = 32

CDG RAT	14
CDG SL	6

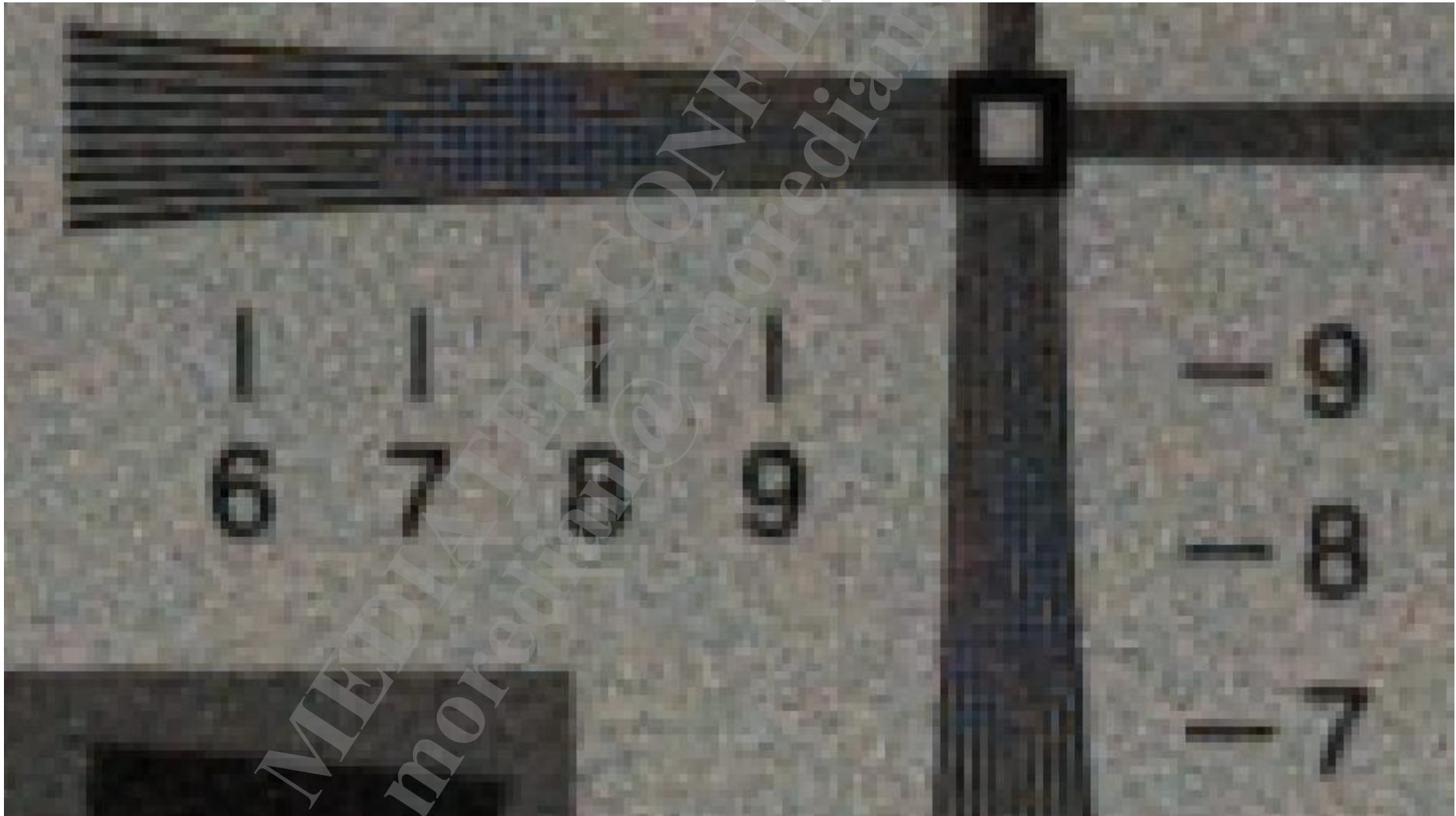
*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



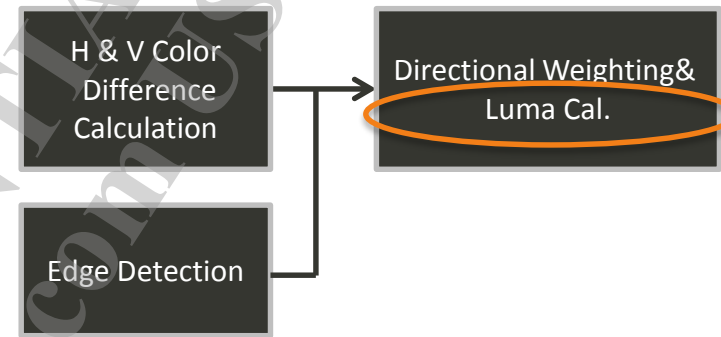
CDG_OFST = 64

CDG RAT	14
CDG SL	6

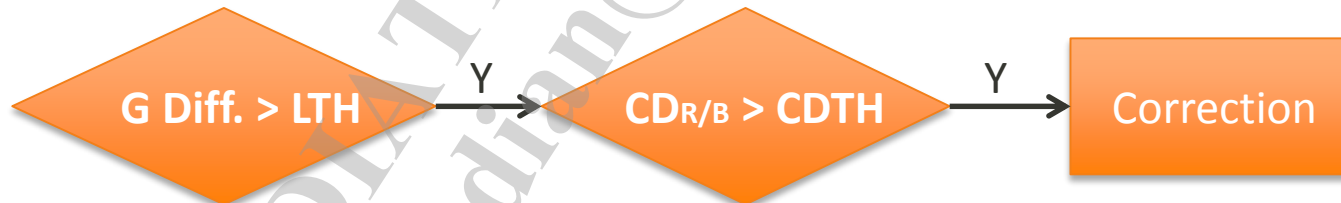
*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	16



1.4 Luma Calculation



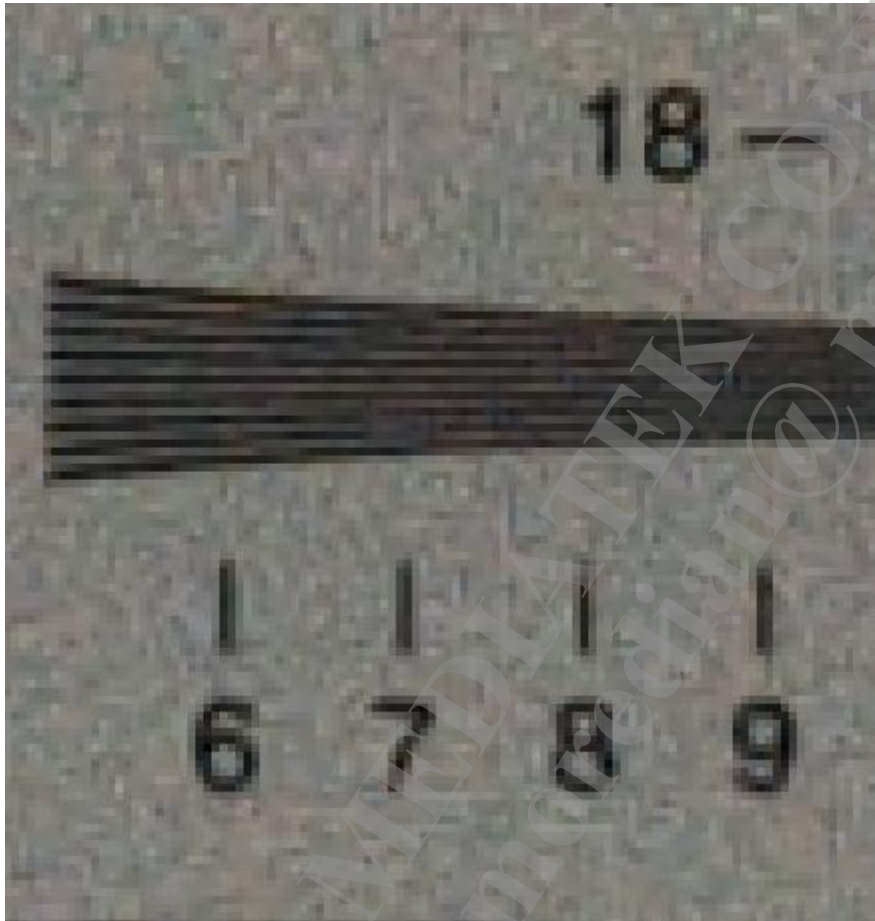
- For each pixel in Bayer domain, estimate lacked channel by CD values (G/R & G/B)
- Single Dot Correction
 - If estimated G value is identified as impulse noise, correct it by surrounding G channel pixels.



✂ Default: LTH = 3, CDTH=5

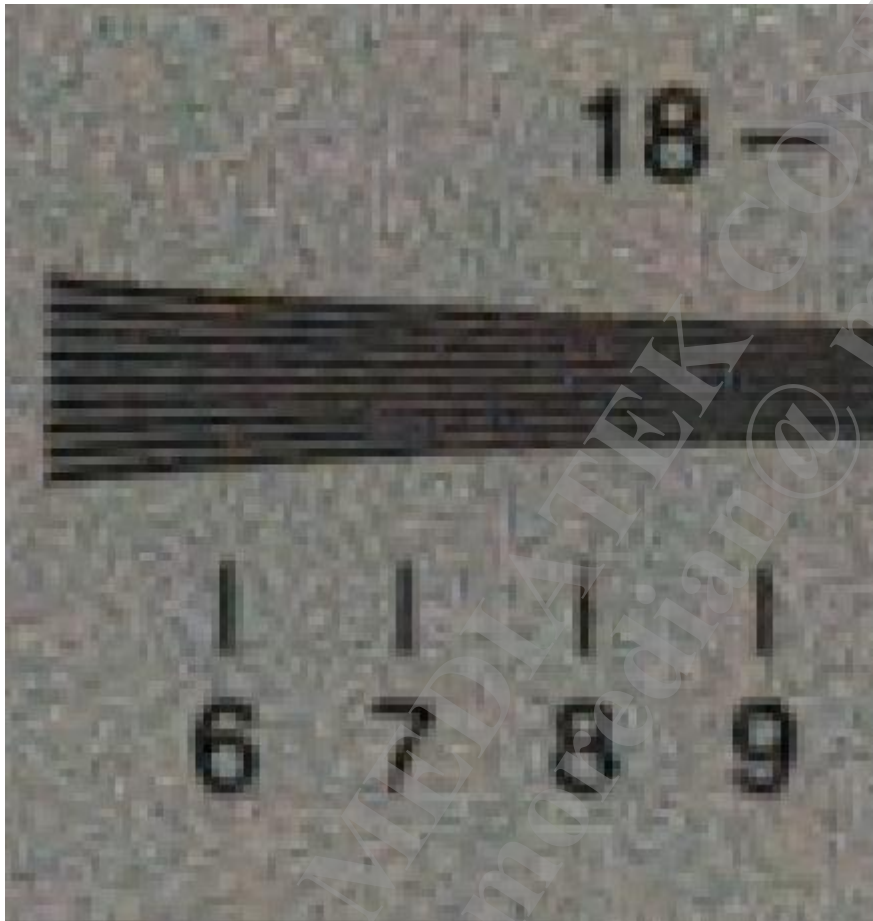
Strong Dot Correction (✖ Default)

*Dot Correction	
INT LTH	3
INT CDTH	5

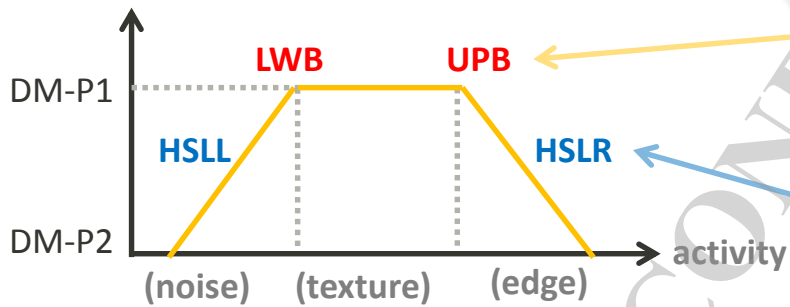


Weak Dot Correction

*Dot Correction	
INT LTH	15
INT CDTH	15



2. DM-P1 & DM-P2 Blending



DM-P1

DM-P2

actbld

DM-P2

P1_BLD (0-16)

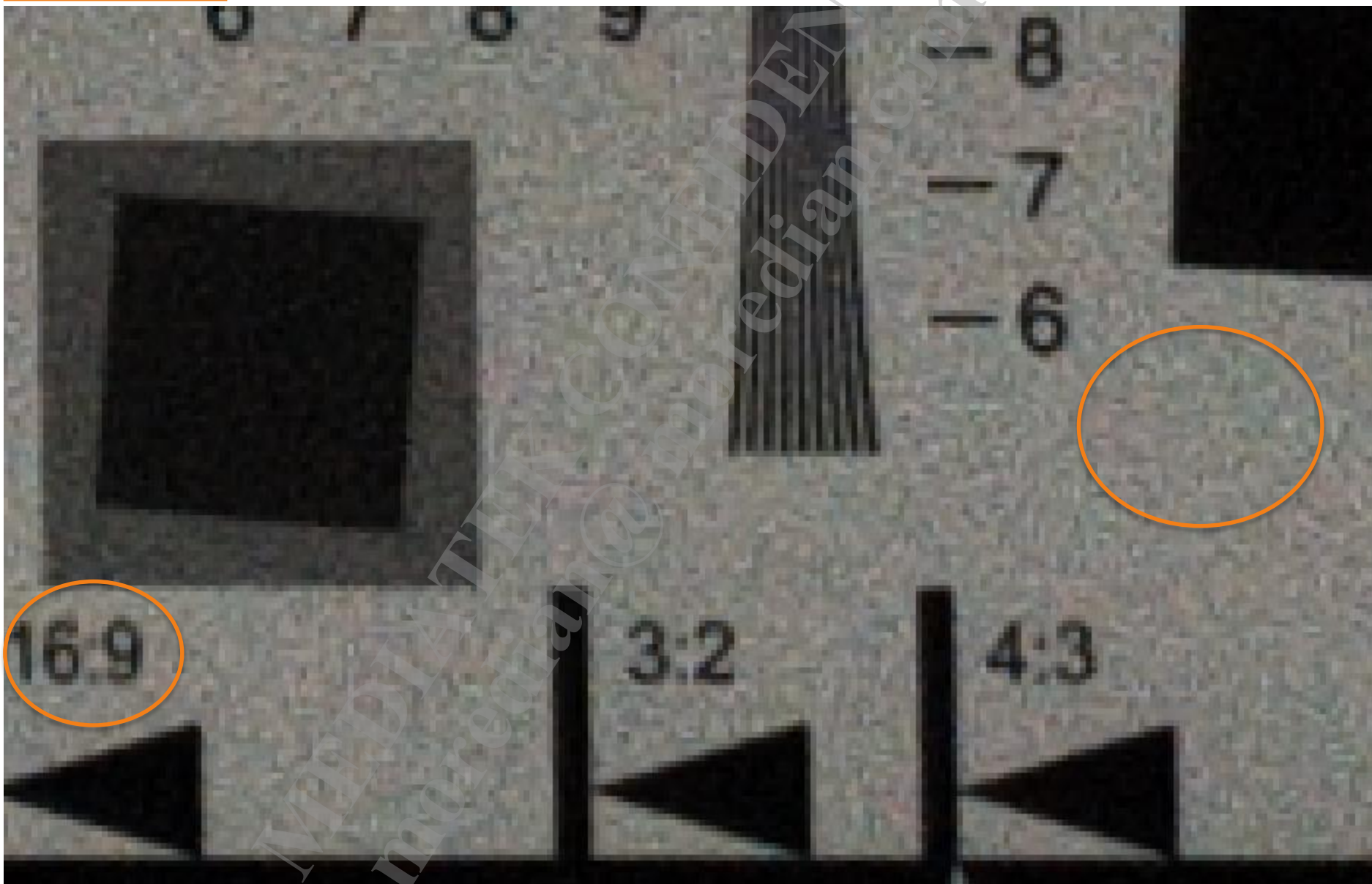
Final

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

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

DM-P1 Result

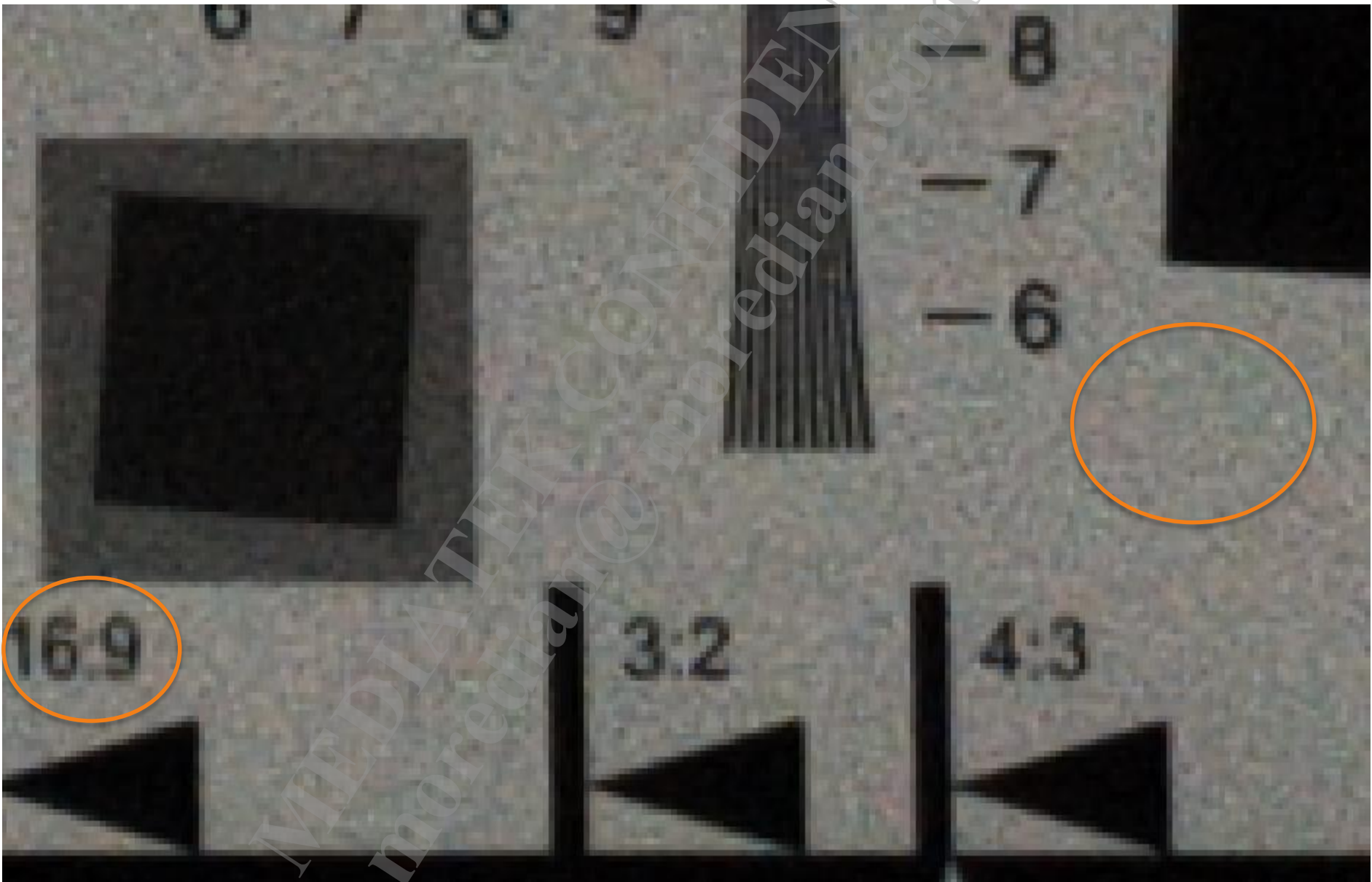
(Noisy)



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

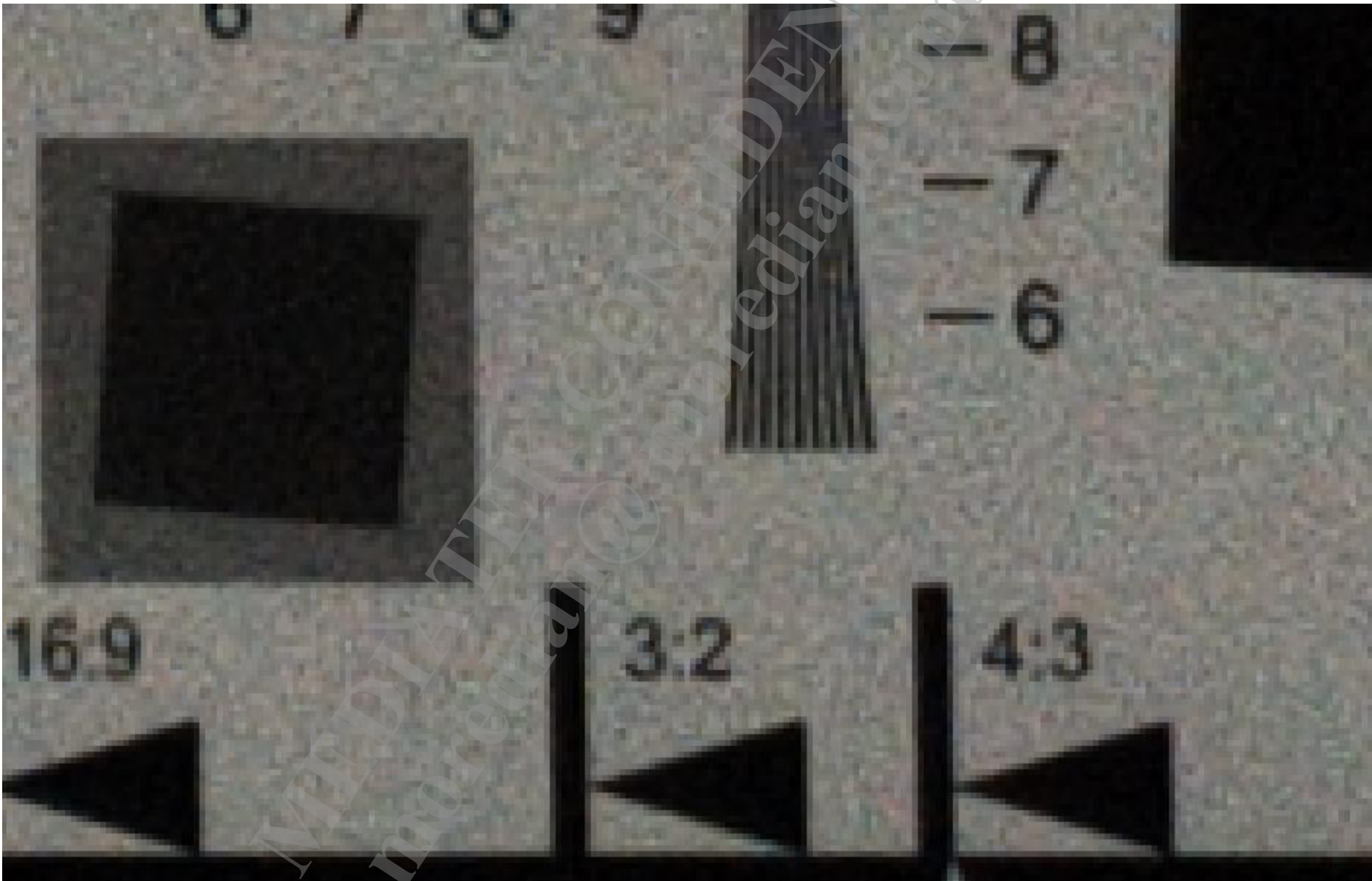
DM-P2 Result

(Blurry Texture)



*P1&P2 Blending	
P1 LWB	0
P1 UPB	255
P1 BLD	8

½ DM-P1 + ½ DM-P2



Blending Tuning Flow

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

P1 BLD	0
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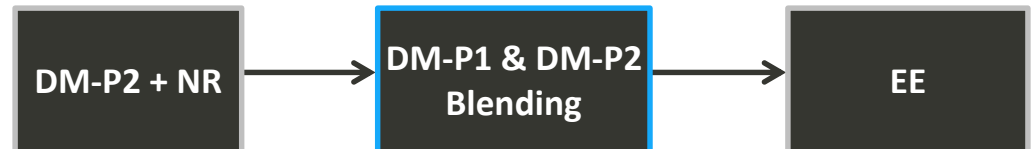
2. If more details is needed, tune DM1 as said above

*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



3. Positive/Negative EE Response

To suppress overshoot or undershoot separately

UDM Mode		HF Gain	11	CrossTalk	
MN MODE	<input type="checkbox"/>	HT GN1	11	XTK RAT	8
BYP	<input type="checkbox"/>	HT GN2	11	XTK OFST	32
*H/V Weight		HD GN1	11	XTK SL	5
CD KNL	<input checked="" type="checkbox"/>	HD GN2	11	RRZ Ratio	
CDG RAT	10	*HD GN3	11	FL MODE	<input type="checkbox"/>
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	<input type="checkbox"/>	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	<input checked="" type="checkbox"/>	N1 OFST	25		
SL Y1	208	N2 OFST	15		
SL Y2	128	NSL	10		
SL HR	16	NGR	0		

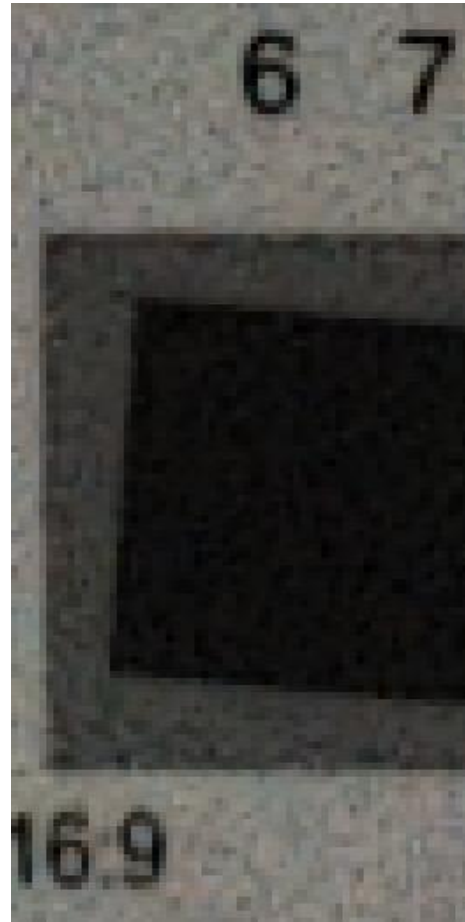
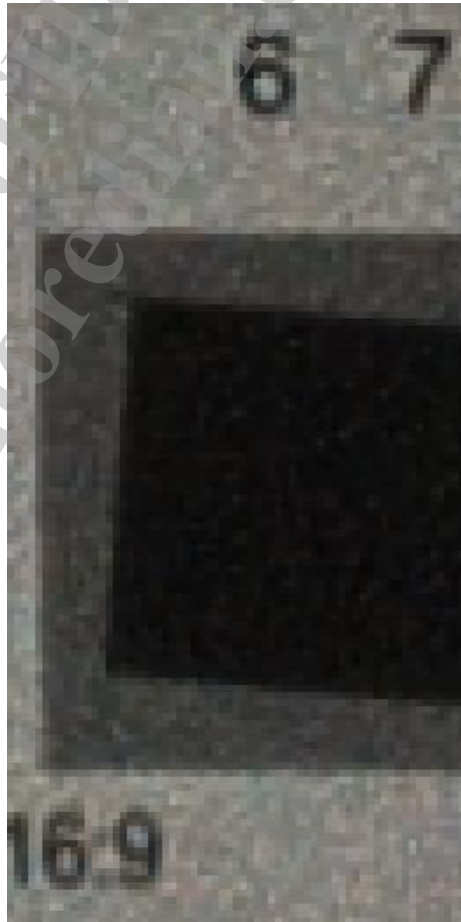
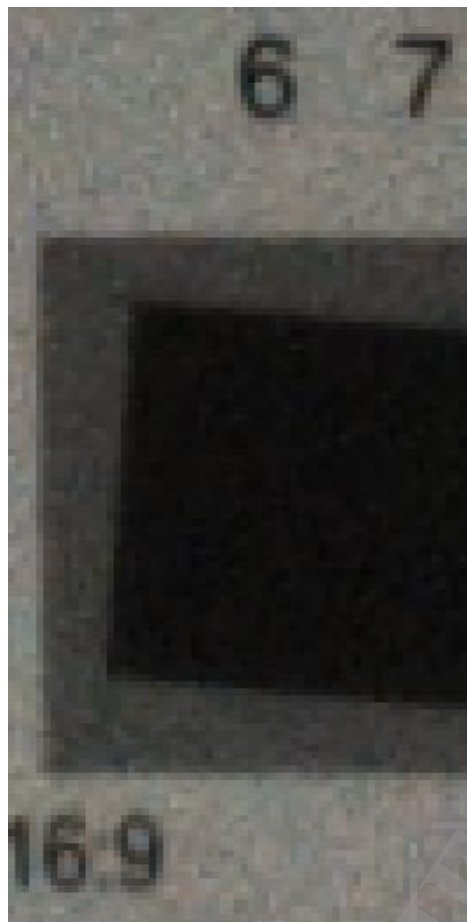
HNEG_GN = 0
HPOS_GN = 0

(※ Default)

HNEG_GN = 16
HPOS_GN = 16

HNEG_GN = 0
HPOS_GN = 16

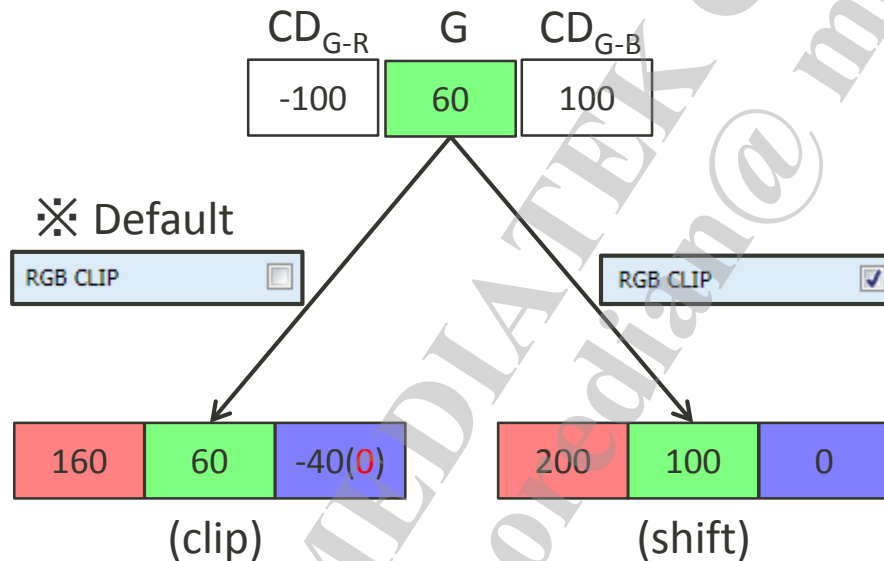
HNEG_GN = 16
HPOS_GN = 0



4. RGB Clipping Recovery

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

(Usually happens in dark red/blue area)



UDM Mode	<input type="checkbox"/>	HF Gain		CrossTalk	
MN MODE	<input type="checkbox"/>	HT GN1	11	XTK RAT	8
BYP	<input type="checkbox"/>	HT GN2	11	XTK OFST	32
*H/V Weight		HD GN1	11	XTK SL	5
CD KNL	<input checked="" type="checkbox"/>	HD GN2	11	RRZ Ratio	
CDG RAT	10	*HD GN3	11	FL MODE	<input type="checkbox"/>
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	<input checked="" type="checkbox"/>	H2 LWB	8		
RGB CLIP	<input checked="" type="checkbox"/>	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				
L0 SL	6	EE Suppress			
L1 OFST	0	CORE TH1	0		
L1 SL	6	CORE TH2	0		
L2 OFST	3	OV TH	255		
L2 SL	6	UN TH	0		
		CLIP TH	0		
LUMA LUT		*HNEG GN	16		
LM Y0	511	*HPOS GN	16		
LM Y1	381				
LM Y2	304	NR STR			
LM Y3	216	N0 STR	10		
LM Y4	137	N1 STR	6		
LM Y5	79	N2 STR	2		
Shading Link		NR ACT LUT			
SL EN	<input checked="" type="checkbox"/>	N0 OFST	25		
SL Y1	208	N1 OFST	25		
SL Y2	128	N2 OFST	15		
SL HR	16	NSL	10		
		NGR	0		

Clipping Recovery OFF

RGB CLIP



Clipping Recovery ON

RGB CLIP



Keep same CD level, but raise luma



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

P23 EE → P40 EE

HF Band Ctrl

HF Band Control

0	H1 D/I BLND OFST
0	H2 D/I BLND OFST
0	H3 D/I BLND OFST
12	H1 D/I BLND SL
12	H2 D/I BLND SL
12	H3 D/I BLND SL
3	HX ISO BLND RAT
4	H1 GN
4	H2 GN
10	H3 GN
0	H4 GN
8	HP CORE TH

Artifact

Overshoot/Dot Artifact

2	Overshoot Clip Str.
6	SingleDot TH
128	SingleDot WF

Clipping

Clipping

25	CLIP
50	CLIP LUMA SPC TH
100	CLIP LUMA LWB
160	CLIP LUMA UPB

Edge LUT

0	X1	0	Y1
40	X2	60	Y2
100	X3	120	Y3
150	X4	120	Y4
255	X5	100	Y5

TH OVR

200

TH UND

200

TH MIN

0

SLNK DEC MAX Y

32

Edge LUT

Save HF EE Info

Luma/Shading Modulation

255	LUMA MOD Y0
255	LUMA MOD Y1
255	LUMA MOD Y2
255	LUMA MOD Y3
255	LUMA MOD Y4
255	LUMA MOD Y5
255	LUMA MOD Y6
0	SLNK EN
255	SLNK GN Y1
255	SLNK GN Y2
16	RESP SLNK GN RAT

Luma/Shading Mod.

EE Gain

Input Edge Response (Ideal / HW)

0

255

EE PBC

HF Band Control

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

GLUT

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

Slow Transition

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

* 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

☐

Luma/Shading Mod

256	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
<input type="checkbox"/>	GLUT LINK EN
255	SLNK GN Y1
255	SLNK GN Y2
16	RESP SLNK RAT

Artifact Control

6	Dot TH
128	DOT REDUC STR
2	OVRSH CLIP STR

*RESP SMO STR

7

Clipping

255	CLIP LUMA UPB
0	CLIP LUMA LWB
0	CLIP LUMA SPC TH
64	RESP CLIP

*YCE

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

*CCE

2	CHR MAXI
2	CHR MINI
3	CHR CNTST LV

*POS GN

16

*NEG GN

16

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

5. Coring by Band

2. YCE/CCE

3. Slow transition

4. Chroma Boost

1. HP smoothing

6. Pos/Neg Gain

EE		PBC		7. PBC	
HF Band Control					
H1 DI BLND OFST	0	X1	35	3. Slow transition	
H2 DI BLND OFST	0	X2	60	Slow Transition	
H3 DI BLND OFST	0	X3	100	ST LB	4
H1 DI BLND SL	12	X4	220	ST UB	12
H2 DI BLND SL	12	Y1	20	ST OFST RESP	100
H3 DI BLND SL	12	Y2	614	ST SL RESP	16
HX ISO BLND RAT	3			ST OFST CE	100
H1 GN	14			ST SL CE	16
H2 GN	4	Y5	41	* Chroma Boost	
H3 GN	1	S1	1	CBOOST EN	<input checked="" type="checkbox"/>
HP CORE TH	8	S2	24	CBOOST GAIN	128
*H1 CORE TH	0	S3	-8	CBOOST LMT L	64
*H2 CORE TH	0	S4	-2	CBOOST LMT U	255
*H3 CORE TH	0	S5	-1	YOFFSET SEL	0
Luma/Shading Mod				YOFFSET	0
LUMA MOD Y0	256	GLUT TH OVR	255	YCONST	4
LUMA MOD Y1	256	GLUT TH UND	255	* LP Mode	
LUMA MOD Y2	256	GLUT TH MIN	0	LP MODE	<input type="checkbox"/>
LUMA MOD Y3	256	GLUT SL DEC Y	32		
LUMA MOD Y4	256	Artifact Control			
LUMA MOD Y5	256	Dot TH	6		
LUMA MOD Y6	256	DOT REDUC STR	128		
GLUT LINK EN	<input type="checkbox"/>	OVRSH CLIP STR	2		
SLNK GN Y1	255	*RESP SMO STR	7	1. HP smoothing	
SLNK GN Y2	255	Clipping			
RESP SLNK RAT	16	CLIP LUMA UPB	255		
*YCE		CLIP LUMA LWB	0		
LUMA MAXI	2	CLIP LUMA SPC TH	0		
LUMA MINI	2	RESP CLIP	64		
LUMA CNTST LV	3	*POS GN	16	6. Pos/Neg Gain	
LUMA LMT DIFF	255	*NEG GN	16		
*CCE					
CHR MAXI	2				
CHR MINI	2				
CHR CNTST LV	3				

1. HP Smoothing

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

EE		PBC	
HF Band Control		GLUT	
H1 DI BLND OFST	0	X1	35
H2 DI BLND OFST	0	X2	60
H3 DI BLND OFST	0	X3	100
H1 DI BLND SL	12	X4	220
H2 DI BLND SL	12	Y1	20
H3 DI BLND SL	12	Y2	614
HX ISO BLND RAT	3	Y3	307
H1 GN	14	Y4	41
H2 GN	4	Y5	41
H3 GN	1	S1	1
HP CORE TH	8	S2	24
*H1 CORE TH	0	S3	-8
*H2 CORE TH	0	S4	-2
*H3 CORE TH	0	S5	-1
Luma/Shading Mod		GLUT TH OVR	
LUMA MOD Y0	256	GLUT TH UND	255
LUMA MOD Y1	256	GLUT TH MIN	0
LUMA MOD Y2	256	GLUT SL DEC Y	32
LUMA MOD Y3	256	Artifact Control	
LUMA MOD Y4	256	Dot TH	6
LUMA MOD Y5	256	DOT REDUC STR	128
LUMA MOD Y6	256	OVRSH CLIP STR	2
GLUT LINK EN	<input type="checkbox"/>	*RESP SMO STR	7
SLNK GN Y1	255	Clipping	
SLNK GN Y2	255	CLIP LUMA UPB	255
RESP SLNK RAT	16	CLIP LUMA LWB	0
*YCE		CLIP LUMA SPC TH	0
LUMA MAXI	2	RESP CLIP	64
LUMA MINI	2	*POS GN	16
LUMA CNTST LV	3	*NEG GN	16
LUMA LMT DIFF	255	*CCE	
*CCE		CHR MAXI	2
		CHR MINI	2
		CHR CNTST LV	3
		* 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	<input checked="" type="checkbox"/>
		CBOOST GAIN	128
		CBOOST LMT L	64
		CBOOST LMT U	255
		YOFFSET SEL	0
		YOFFSET	0
		YCONST	4
		* LP Mode	
		LP MODE	<input type="checkbox"/>

EE OFF

SMO_STR = 0

✖ Default

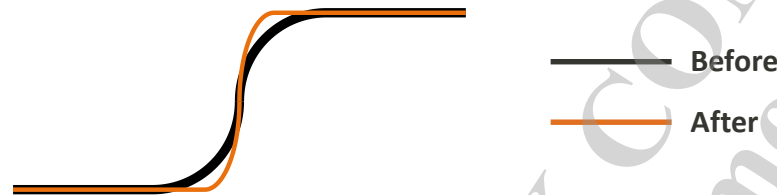
SMO_STR = 4

SMO_STR = 7



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		GLUT	
H1 DI BLND OFST	0	X1	35
H2 DI BLND OFST	0	X2	60
H3 DI BLND OFST	0	X3	100
H1 DI BLND SL	12	X4	220
H2 DI BLND SL	12	Y1	20
H3 DI BLND SL	12	Y2	614
HX ISO BLND RAT	3	Y3	307
H1 GN	14	Y4	41
H2 GN	4	Y5	41
H3 GN	1	S1	1
HP CORE TH	8	S2	24
*H1 CORE TH	0	S3	-8
*H2 CORE TH	0	S4	-2
*H3 CORE TH	0	S5	-1
Luma/Shading Mod		GLUT TH OVR	
LUMA MOD Y0	256	GLUT TH UND	255
LUMA MOD Y1	256	GLUT TH MIN	0
LUMA MOD Y2	256	GLUT SL DEC Y	32
LUMA MOD Y3	256	Artifact Control	
LUMA MOD Y4	256	Dot TH	6
LUMA MOD Y5	256	DOT REDUC STR	128
LUMA MOD Y6	256	OVR5H CLIP STR	2
GLUT LINK EN	<input type="checkbox"/>	*RESP SMO STR	7
SLNK GN Y1	255	Clipping	
SLNK GN Y2	255	CLIP LUMA UPB	255
RESP SLNK RAT	16	CLIP LUMA LWB	0
*YCE		CLIP LUMA SPC TH	0
LUMA MAXI	2	RESP CLIP	64
LUMA MINI	2	*POS GN	16
LUMA CNTST LV	4	*NEG GN	16
LUMA LMT DIFF	255	* Slow Transition	
*CCE		ST LB	4
CHR MAXI	2	ST UB	12
CHR MINI	2	ST OFST RESP	100
CHR CNTST LV	4	ST SL RESP	16
		ST OFST CE	100
		ST SL CE	16
		* Chroma Boost	
		CBOOST EN	<input checked="" type="checkbox"/>
		CBOOST GAIN	128
		CBOOST LMT L	64
		CBOOST LMT U	255
		YOFFSET SEL	0
		YOFFSET	0
		YCONST	4
		* LP Mode	
		LP MODE	<input type="checkbox"/>

EE OFF

HP Only

YCE/CCE Only



YCE/CCE Registers

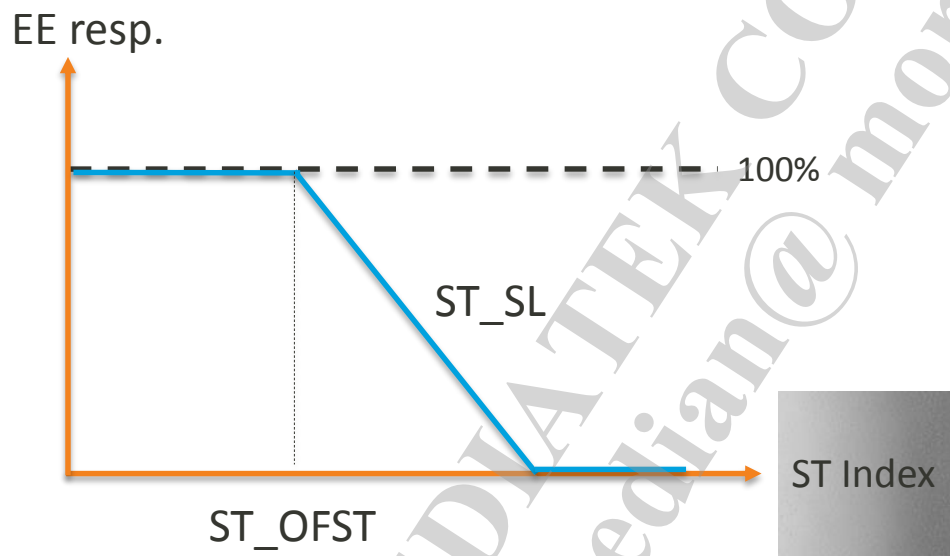
*YCE	
LUMA MAXI	2
LUMA MINI	2
LUMA CNTST LV	4
LUMA LMT DIFF	255
*CCE	
CHR MAXI	2
CHR MINI	2
CHR CNTST LV	4

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.

3. Slow Transition

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



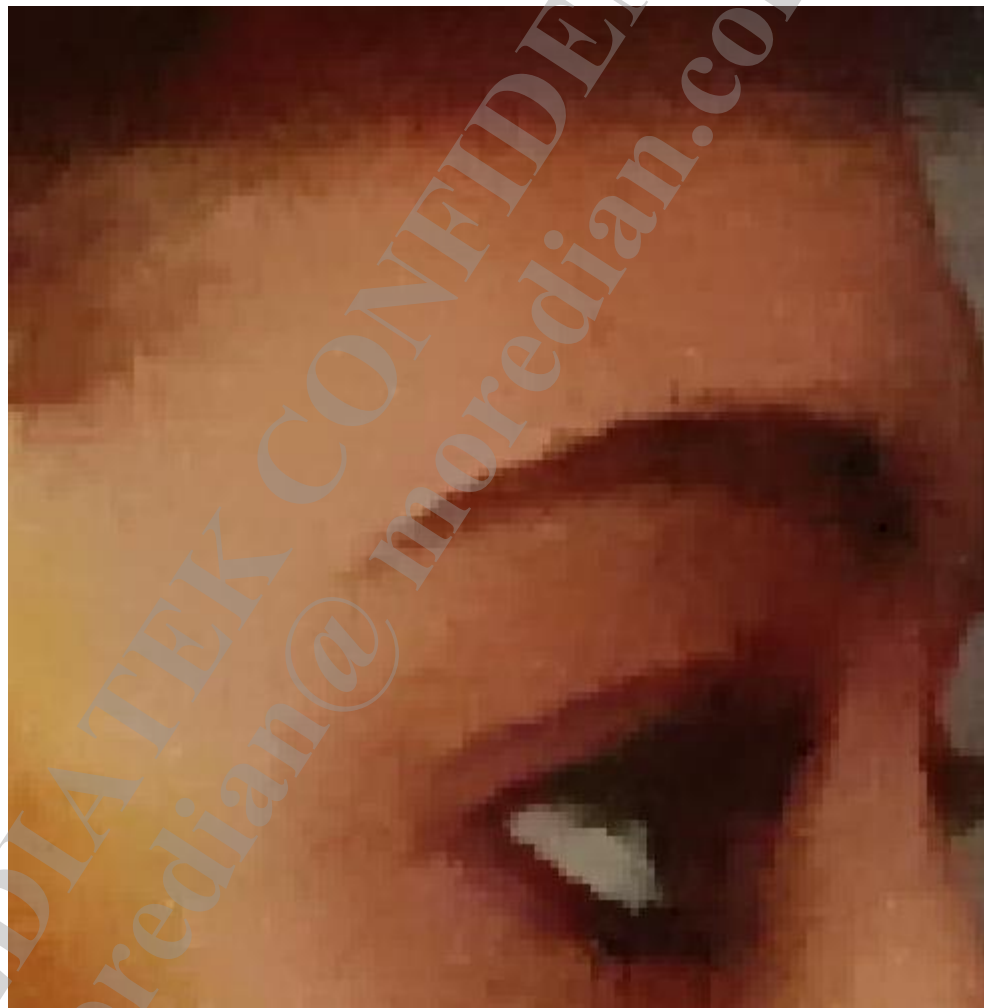
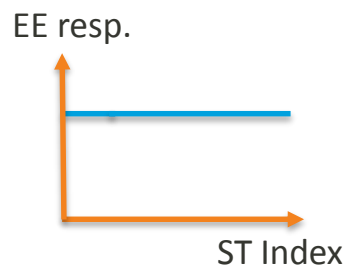
EE		PBC	
HF Band Control			
H1 DI BLND OFST	0	X1	35
H2 DI BLND OFST	0	X2	60
H3 DI BLND OFST	0	X3	100
H1 DI BLND SL	12	X4	220
H2 DI BLND SL	12	Y1	20
H3 DI BLND SL	12	Y2	614
HX ISO BLND RAT	3	Y3	307
H1 GN	14	Y4	41
H2 GN	4	Y5	41
H3 GN	1	S1	1
HP CORE TH	8	S2	24
*H1 CORE TH	0	S3	-8
*H2 CORE TH	0	S4	-2
*H3 CORE TH	0	S5	-1
Luma/Shading Mod		GLUT TH OVR	
LUMA MOD Y0	256	GLUT TH UND	255
LUMA MOD Y1	256	GLUT TH MIN	0
LUMA MOD Y2	256	GLUT SL DEC Y	32
LUMA MOD Y3	256	Artifact Control	
LUMA MOD Y4	256	Dot TH	6
LUMA MOD Y5	256	DOT REDUC STR	128
LUMA MOD Y6	256	OVRSH CLIP STR	2
GLUT LINK EN	<input type="checkbox"/>	*RESP SMO STR	7
SLNK GN Y1	255	Clipping	
SLNK GN Y2	255	CLIP LUMA UPB	255
RESP SLNK RAT	16	CLIP LUMA LWB	0
*YCE		CLIP LUMA SPC TH	0
LUMA MAXI	2	RESP CLIP	64
LUMA MINI	2	*POS GN	16
LUMA CNTST LV	3	*NEG GN	16
LUMA LMT DIFF	255	*CCE	
*CCE		CHR MAXI	2
		CHR MINI	2
		CHR CNTST LV	3
<div>Slow Transition</div> <div>ST LB 4</div> <div>ST UB 12</div> <div>ST OFST RESP 100</div> <div>ST SL RESP 16</div> <div>ST OFST CE 100</div> <div>ST SL CE 16</div>			
<div>* Chroma Boost</div> <div>CBOOST EN <input checked="" type="checkbox"/></div> <div>CBOOST GAIN 128</div> <div>CBOOST LMT L 64</div> <div>CBOOST LMT U 255</div> <div>YOFFSET SEL 0</div> <div>YOFFSET 0</div> <div>YCONST 4</div>			
<div>* LP Mode</div> <div>LP MODE <input type="checkbox"/></div>			

Slow transition Registers

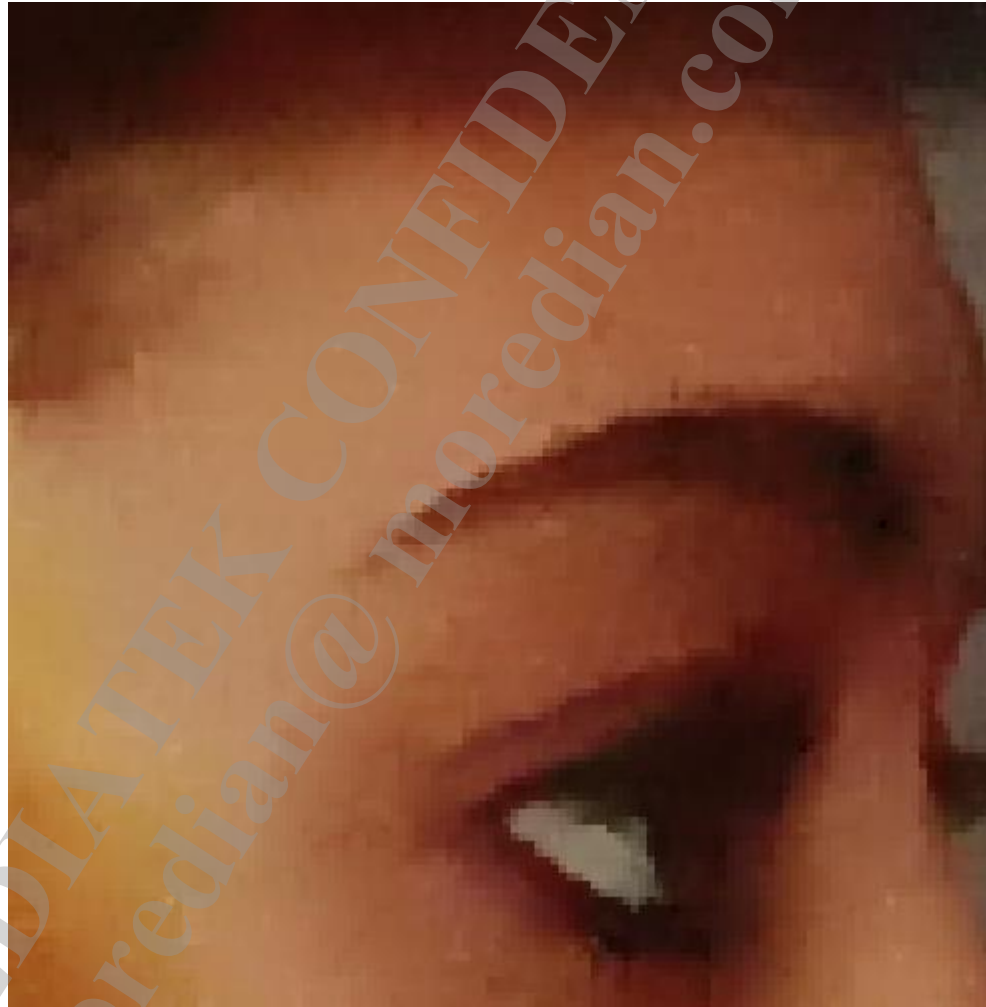
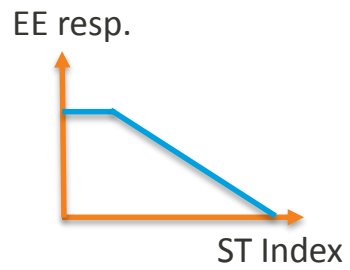
Reg name	Range	Description	※Suggest
ST_LB	0~255	Slow transition index lower bound	1~3
ST_UB	0~255	Slow transition index upper bound	9~12
ST_OFST_RESP	0~255	HP response slow trans. offset	96~128
ST_SL_RESP	0~255	HP response slow trans. slope	2~4
ST_OFST_CE	0~255	YCE/CCE slow trans. offset	96~128
ST_SL_CE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

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

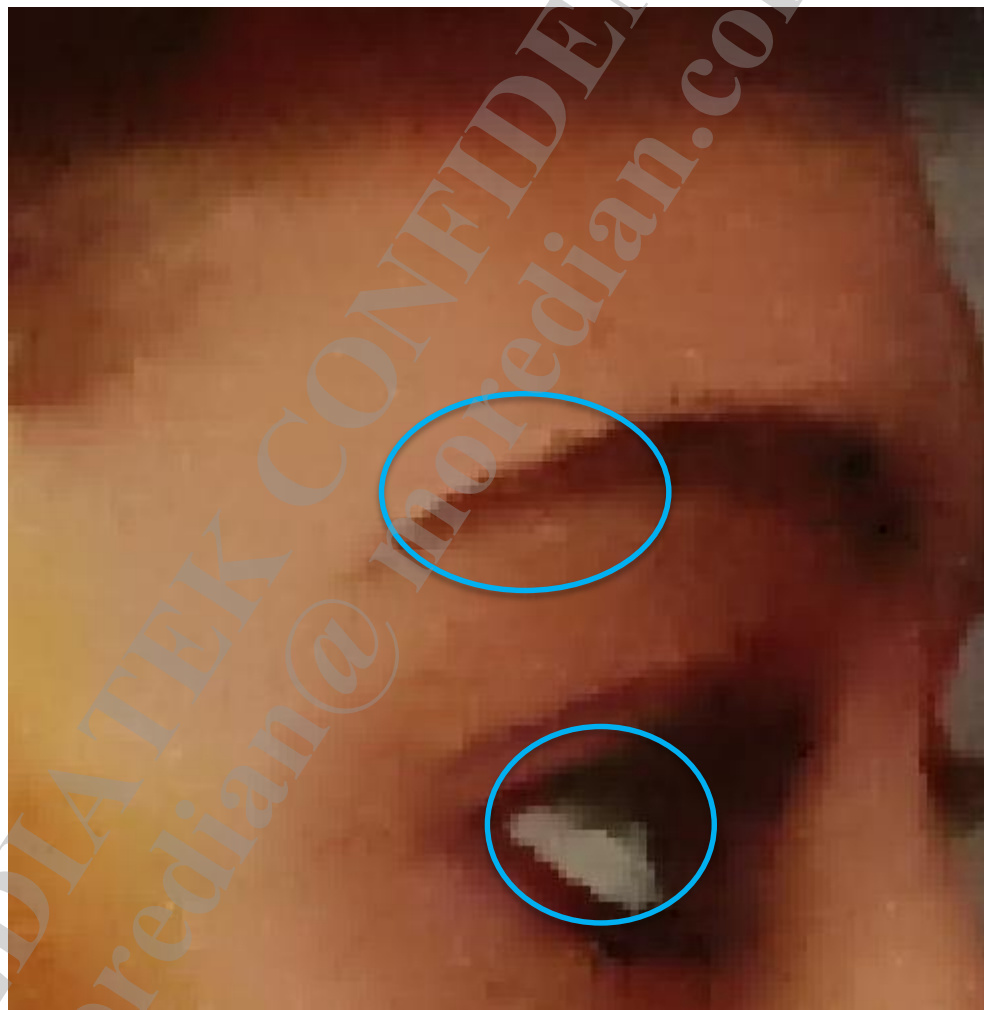
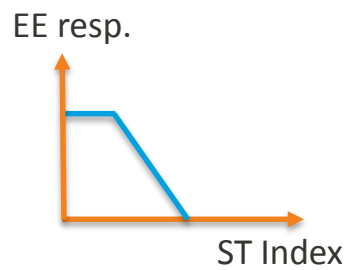
$ST_SL_RESP = ST_SL_CE = 0$ (ST Disable)



$$\text{ST_SL_RESP} = \text{ST_SL_CE} = 4$$



$$\text{ST_SL_RESP} = \text{ST_SL_CE} = 16$$



4. Chroma Boost

- Compensate UV channel based on Y

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

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

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

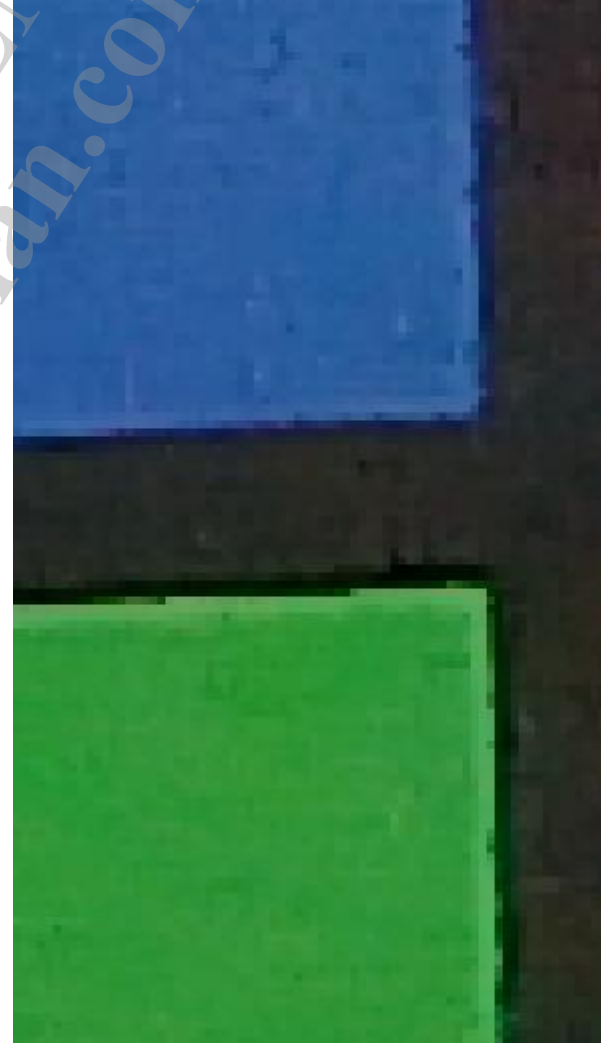
$$Y_{ofst} = \min(Y_{In} \gg \text{YOFFSET_SEL}, \text{YOFFSET})$$

EE	PBC		
HF Band Control		GLUT	
H1 DI BLND OFST	0	X1	35
H2 DI BLND OFST	0	X2	60
H3 DI BLND OFST	0	X3	100
H1 DI BLND SL	12	X4	220
H2 DI BLND SL	12	Y1	20
H3 DI BLND SL	12	Y2	614
HX ISO BLND RAT	3	Y3	307
H1 GN	14	Y4	41
H2 GN	4	Y5	41
H3 GN	1	S1	1
HP CORE TH	8	S2	24
*H1 CORE TH	0	S3	-8
*H2 CORE TH	0	S4	-2
*H3 CORE TH	0	S5	-1
Luma/Shading Mod		GLUT TH OVR	
LUMA MOD Y0	256	GLUT TH UND	
LUMA MOD Y1	256	GLUT TH MIN	
LUMA MOD Y2	256	GLUT SL DEC Y	
LUMA MOD Y3	256	Artifact Control	
LUMA MOD Y4	256	Dot TH	
LUMA MOD Y5	256	DOT REDUC STR	
LUMA MOD Y6	256	OVRSH CLIP STR	
GLUT LINK EN	<input type="checkbox"/>	*RESP SMO STR	
SLNK GN Y1	255	Clipping	
SLNK GN Y2	255	CLIP LUMA UPB	
RESP SLNK RAT	16	CLIP LUMA LWB	
*YCE		CLIP LUMA SPC TH	
LUMA MAXI	2	RESP CLIP	
LUMA MINI	2	*POS GN	
LUMA CNTST LV	3	*NEG GN	
LUMA LMT DIFF	255		
*CCE			
CHR MAXI	2		
CHR MINI	2		
CHR CNTST LV	3		
		* Slow Transition	
		ST LB	
		ST UB	
		ST OFST RESP	
		ST SL RESP	
		ST OFST CE	
		ST SL CE	
		Chroma Boost	
		CBOOST EN	
		CBOOST GAIN	
		CBOOST LMT L	
		CBOOST LMT U	
		YOFFSET SEL	
		YOFFSET	
		YCONST	
		* LP Mode	
		LP MODE	

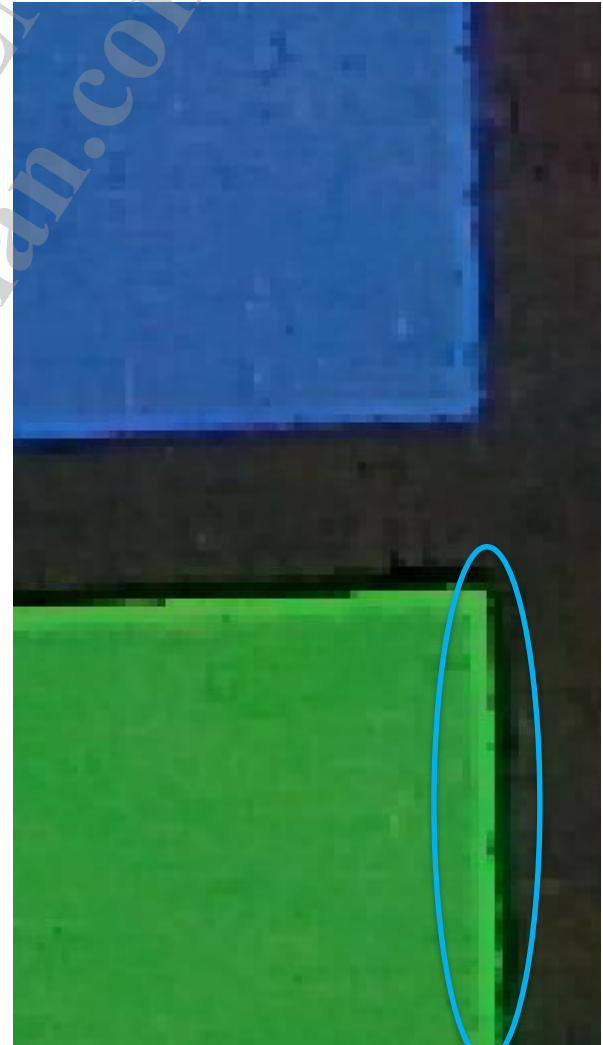
Chroma Boost Registers

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

CBOOST_GAIN = 0 (OFF)



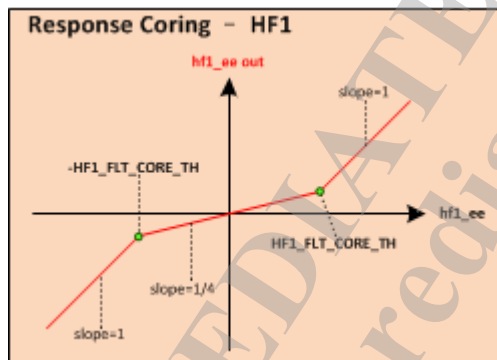
CBOOST_GAIN = 128 (1x)



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		GLUT	
H1 DI BLND OFST	0	X1	35
H2 DI BLND OFST	0	X2	60
H3 DI BLND OFST	0	X3	100
H1 DI BLND SL	12	X4	220
H2 DI BLND SL	12	Y1	20
H3 DI BLND SL	12	Y2	614
HX ISO BLND RAT	3	Y3	307
H1 GN	14	Y4	41
H2 GN	4	Y5	41
H3 GN	1	S1	1
HP CORE TH	8	S2	24
*H1 CORE TH	0	S3	-8
*H2 CORE TH	0	S4	-2
*H3 CORE TH	0	S5	-1
Luma/Shading Mod		GLUT TH OVR	255
LUMA MOD Y0	256	GLUT TH UND	255
LUMA MOD Y1	256	GLUT TH MIN	0
LUMA MOD Y2	256	GLUT SL DEC Y	32
LUMA MOD Y3	256	Artifact Control	
LUMA MOD Y4	256	Dot TH	6
LUMA MOD Y5	256	DOT REDUC STR	128
LUMA MOD Y6	256	OVRSH CLIP STR	2
GLUT LINK EN	<input type="checkbox"/>	*RESP SMO STR	7
SLNK GN Y1	255	Clipping	
SLNK GN Y2	255	CLIP LUMA UPB	255
RESP SLNK RAT	16	CLIP LUMA LWB	0
*YCE		CLIP LUMA SPC TH	0
LUMA MAXI	2	RESP CLIP	64
LUMA MINI	2	*POS GN	16
LUMA CNTST LV	3	*NEG GN	16
LUMA LMT DIFF	255	*CCE	
*CCE		CHR MAXI	2
		CHR MINI	2
		CHR CNTST LV	3
		* 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	<input checked="" type="checkbox"/>
		CBOOST GAIN	128
		CBOOST LMT L	64
		CBOOST LMT U	255
		YOFFSET SEL	0
		YOFFSET	0
		YCONST	4
		* LP Mode	
		LP MODE	<input type="checkbox"/>

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

EE PBC

HF Band Control	GLUT	* Slow Transition
H1 DI BLND OFST 0	X1 35	ST LB 4
H2 DI BLND OFST 0	X2 60	ST UB 12
H3 DI BLND OFST 0	X3 100	ST OFST RESP 100
H1 DI BLND SL 12	X4 220	ST SL RESP 16
H2 DI BLND SL 12	Y1 20	ST OFST CE 100
H3 DI BLND SL 12	Y2 614	ST SL CE 16
HX ISO BLND RAT 3	Y3 307	
H1 GN 14	Y4 41	* Chroma Boost
H2 GN 4	Y5 41	CBOOST EN <input checked="" type="checkbox"/>
H3 GN 1	S1 1	CBOOST GAIN 128
HP CORE TH 8	S2 24	CBOOST LMT L 64
*H1 CORE TH 0	S3 -8	CBOOST LMT U 255
*H2 CORE TH 0	S4 -2	YOFFSET SEL 0
*H3 CORE TH 0	S5 -1	YOFFSET 0
		YCONST 4
		* LP Mode
		LP MODE <input type="checkbox"/>
Luma/Shading Mod	GLUT TH OVR 255	
LUMA MOD Y0 256	GLUT TH UND 255	
LUMA MOD Y1 256	GLUT TH MIN 0	
LUMA MOD Y2 256	GLUT SL DEC Y 32	
LUMA MOD Y3 256		Artifact Control
LUMA MOD Y4 256		Dot TH 6
LUMA MOD Y5 256		DOT REDUC STR 128
LUMA MOD Y6 256		OVRSH CLIP STR 2
GLUT LINK EN <input type="checkbox"/>		*RESP SMO STR 7
SLNK GN Y1 255		Clipping
SLNK GN Y2 255		CLIP LUMA UPB 255
RESP SLNK RAT 16		CLIP LUMA LWB 0
		CLIP LUMA SPC TH 0
*YCE		RESP CLIP 64
LUMA MAXI 2		*POS GN 16
LUMA MINI 2		*NEG GN 16
LUMA CNTST LV 3		
LUMA LMT DIFF 255		
*CCE		
CHR MAXI 2		
CHR MINI 2		
CHR CNTST LV 3		

POS GN = 16

NRG GN = 16



POS GN = 16

NRG GN = 0



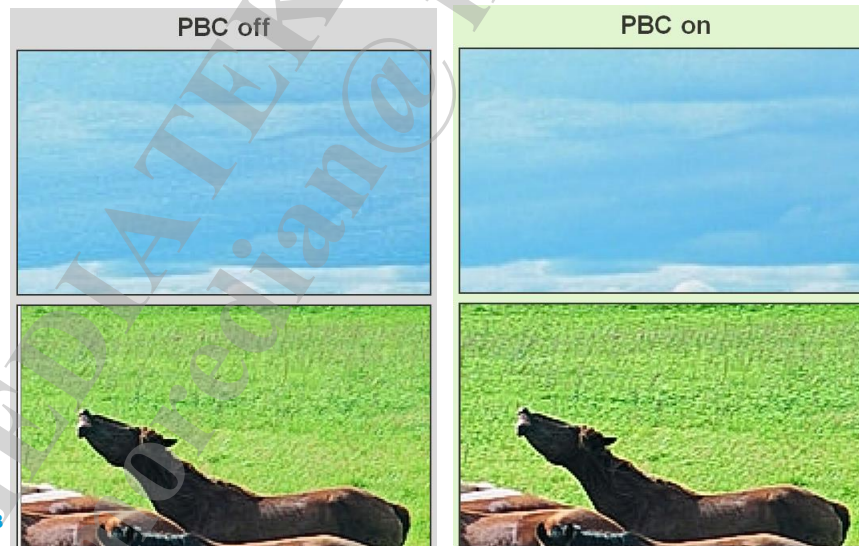
POS GN = 0
NRG GN = 16



7. PBC (Peaking By Color)

- Color dependent EE/blurring
- 3 color region supported (PBC1, PBC2, PBC3)

EE	PBC	SE2	SE
* PBC1			
PBC1 EN	<input type="checkbox"/>		
PBC1 EN	<input checked="" type="checkbox"/>		
PBC1 RSLOPE 1		39	
PBC1 RSLOPE		85	
PBC1 RADIUS R		42	
PBC1 RADIUS C		48	
PBC1 THETA C		149	
PBC1 THETA R		24	
PBC1 TSLOPE		85	
PBC1 GAIN		52	
PBC1 CONF GAIN		1	
PBC1 EDGE THR		63	
PBC1 EDGE SLOPE		8	
PBC1 EDGE EN	<input type="checkbox"/>		
PBC1 LPF EN	<input type="checkbox"/>		
PBC1 LPF GAIN		16	
* PBC2			
PBC2 EN	<input checked="" type="checkbox"/>		
PBC2 RSLOPE 1		32	
PBC2 RSLOPE		43	
PBC2 RADIUS R		40	
PBC2 RADIUS C		48	
PBC2 THETA C		88	
PBC2 THETA R		24	
PBC2 TSLOPE		43	
PBC2 GAIN		24	
PBC2 CONF GAIN		4	
PBC2 EDGE THR		32	
PBC2 EDGE SLOPE		24	
PBC2 EDGE EN	<input checked="" type="checkbox"/>		
PBC2 LPF EN	<input checked="" type="checkbox"/>		
PBC2 LPF GAIN		12	
* PBC3			
PBC3 EN	<input checked="" type="checkbox"/>		
PBC3 RSLOPE 1		17	
PBC3 RSLOPE		32	
PBC3 RADIUS R		42	
PBC3 RADIUS C		60	
PBC3 THETA C		224	
PBC3 THETA R		32	
PBC3 TSLOPE		64	
PBC3 GAIN		24	
PBC3 CONF GAIN		1	
PBC3 EDGE THR		8	
PBC3 EDGE SLOPE		24	
PBC3 EDGE EN	<input checked="" type="checkbox"/>		
PBC3 LPF EN	<input checked="" type="checkbox"/>		
PBC3 LPF GAIN		8	



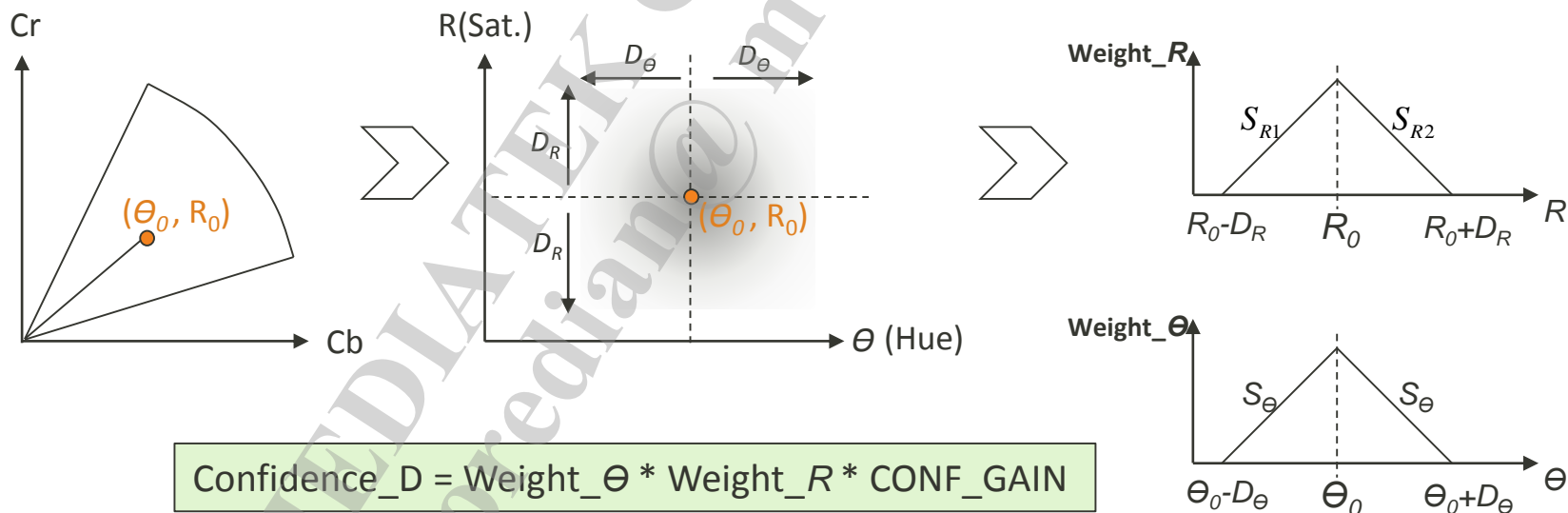
(Lower EE in blue region)

(Higher EE in green region)

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	

PBC1 EN	<input checked="" type="checkbox"/>
PBC1 RSLOPE 1	39
PBC1 RSLOPE	85
PBC1 RADIUS R	42
PBC1 RADIUS C	48
PBC1 THETA C	149
PBC1 THETA R	24
PBC1 TSLOPE	85
PBC1 GAIN	52
PBC1 CONF GAIN	1
PBC1 EDGE THR	63
PBC1 EDGE SLOPE	8
PBC1 EDGE EN	<input type="checkbox"/>

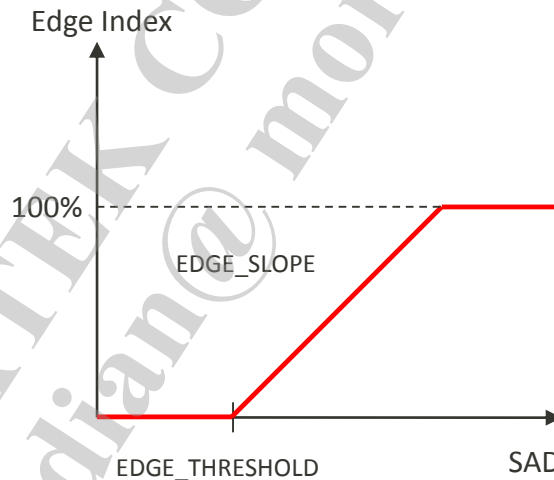


7.2 Edge Preserve Registers

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

PBC1 EN	<input checked="" type="checkbox"/>
PBC1 RSLOPE 1	39
PBC1 RSLOPE	85
PBC1 RADIUS R	42
PBC1 RADIUS C	48
PBC1 THETA C	149
PBC1 THETA R	24
PBC1 TSLOPE	85
PBC1 GAIN	52
PBC1 CONF GAIN	1
PBC1 EDGE THR	63
PBC1 EDGE SLOPE	8
PBC1 EDGE EN	<input type="checkbox"/>



$$\text{Confidence_E} = \text{Confidence_D} * (100\% - \text{Edge_Index})$$

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