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(72) 90004 52-103 3333

85283 7929

85248 1872

(74)

(54)

VLSI

2

, , , , , DWT

가

SI(Very Large Scale Integrated) DWT (Discrete Wavelet Transform) 가  
DCT(discrete cosine transform) DWT (Discrete Wavelet Transform)  
DWT (discrete)

DWT 2 - - - 2 - - -  
- - -  
- - -  
, DWT , , ,  
VLSI VLSI DWT  
VLSI 가 . DWT 100  
DWT

(SB) , N -

1								
2								
3	가	2		2	가		가	2
4	가	2		2	가		가	3
5		가	2		2	가		가
6	가	2		2		가	가	5
7		$L_0 - L_4$			2			
8					2			4

,

## DWT (Discrete Wavelet Transform)

$$L_n = \frac{h_{2n-k}}{h_i} d_k, H_n = \frac{g_{2n-k}}{g_i} d_k \quad n=0,1,\dots N/2-1$$

9-7 8-7

$$h_{-s}h_{-1}h_{-s}h_{-1}h_{-s}h_{-s}h_{-1}) = 7$$

11.  $-2, -1, 0, 1, 2, 3, 4$ )  $\therefore$   
9. 7

$$L_0 = h_0d_0 + 2h_{-1}d_1 + 2h_{-2}d_2 + 2h_{-3}d_3 + 2h_{-4}d_4$$

$$L_1 = h_2d_0 + h_1d_1 + h_0d_2 + h_{-1}d_3 + h_{-2}d_4 +$$

$$L_2 = h_4d_0 + h_3d_1 + h_2d_2 + h_1d_3 + h_0d_4 + h_5$$

$$I_{12} = h_1(d_1 + d_2) + h_2(d_1 + d_2) + h_3(d_1 + d_2) +$$

$$L_0 = h_0(d_0 + d_0) + h_1(d_1 + d_1) + h_2(d_2 + d_2)$$

$$L_2 = h_0(0 + d_4) + h_1(d_3 + d_5) + h_2(d_2 + d_6)$$

$L_i$  .

9 - 7

$$H_0 = g_0 d_1 + g_1(d_0 + d_2) + g_2(d_1 + d_3) + g_3(d_2 + d_4)$$

$$H_1 = g_0d_3 + g_1(d_2 + d_4) + g_2(d_1 + d_5) + g_3(d_6 + d_7)$$

$$H_{-i}$$

N/2 , 1 9-7 - - DWT N- N/2 -  
 - - - - - - - - (significance)  
 , , ,  $h_{-i} = h_i$   $g_{-i} = g_i$  가 1 . 1 , , ,  
 9- - - -  $h_i$  7- - - g . . .  
 , , , , , 1 , , ,  
 1 ,  
 $L_0 = h_0d_0 + h_1d_1 + h_2d_2 + h_3d_3 + h_4d_4$   
 $H_0 = g_0d_1 + g_1(d_0 + d_2) + g_2(d_1 + d_3) + g_3(d_2 + d_4)$   
 , L , H  
 1 (104, 106) 1  $d_0 - d_7$  (108) 1  
 ) (102)  $d_0 - d_1, d_2, d_3, d_4$  (102)(  
 $d_1, d_2, d_3, d_4$   $d_0$  (110)  
 1 16- 4  $h_0, h_1, h_2, h_3$   $d_i$   $g_0, g_1, g_2, g_3$   
 , (102)  $d_i$   $h_i$  가  
 , (112, 114) 가  $h_i$   
 $d_i$   
 $h_4d_4, h_3d_3, h_2d_2, h_1d_1, h_0d_0, h_1d_1, h_2d_2, h_3d_3, \text{ and } h_4d_4$ ,  
 $L_0 = h_0d_0 + h_1d_1 + h_2d_2 + h_3d_3 + h_4d_4$ .  
 가 가 , ,  $g_i$   $d_i$   
 $g_3d_2, g_2d_1, g_1d_0, g_0d_1, g_1d_2, g_2d_3, g_3d_4$   
 $H_0 = g_0d_1 + g_1(d_0 + d_2) + g_2(d_1 + d_3) + g_3(d_2 + d_4)$ .  
 2 2 ,  $h_i$  (116)  $g_i$  (118) 2  
 $h_i$   $d_i$   $h_i$   $d_i$   
 $h_4d_2, h_3d_1, h_2d_0, h_1d_1, h_0d_2, h_1d_3, h_2d_4, h_3d_5$  and  $h_4d_6$ .  
 가  
 $L_1 = h_0d_2 + h_1(d_1 + d_3) + h_2(d_0 + d_4) + h_3(d_1 + d_5) + h_4(d_2 + d_6)$ .  
 ,  $H_1$   $d_i$  1 2  
 $g_i$  , ,  
 $H_1$  2  
 $H_1 = g_0d_3 + g_1(d_2 + d_4) + g_2(d_1 + d_5) + g_3(d_0 + d_6)$ .  
 1 , , , , , , ,  
 2 , , , , , , ,  
 $(200) N$  , , , , , , ,  
 $, N-$  , , , , , , ,  
 $(201) 9$  , , , , , , ,  
 $N-$  , , , , , , ,  
 $(202, 204, 206, 208, 210, 212, 214, 216, 218)$  , , , , , , ,  
 16-  $d_i$  , , , , , , ,  
 16- , , , , , , ,  
 $R_i$  , , , , , , ,  
 $d_0, d_1, d_2$  , , , , , , ,  
 R

R<sub>i</sub>

5      d<sub>0</sub> - d<sub>4</sub>      d<sub>0</sub> - d<sub>4</sub> 가      (264)      (264)  
       (266)      (260, 262)      (266)      1      4      1  
       (266)      (260, 262)  
       d<sub>0</sub> - d<sub>4</sub>      R<sub>0</sub>, R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>  
       (200)      R<sub>0</sub> d<sub>4</sub>, R<sub>1</sub> d<sub>3</sub>, R<sub>2</sub> d<sub>2</sub>, R<sub>3</sub> d<sub>1</sub>, R<sub>4</sub> d<sub>0</sub>  
       (200)      d<sub>0</sub>, d<sub>1</sub>, d<sub>2</sub>, d<sub>3</sub>, d<sub>4</sub>      (200)  
       d<sub>0</sub> - d<sub>4</sub> 가      R<sub>4</sub> - R<sub>0</sub>  
       (268, 270, 272, 274)      R<sub>4</sub>  
       R<sub>5</sub>, R<sub>6</sub>, R<sub>7</sub>, R<sub>8</sub>      R<sub>6</sub>, d<sub>3</sub>      R<sub>7</sub>, R<sub>1</sub>      R<sub>8</sub>, R<sub>4</sub>  
       (200)      R<sub>7</sub>, R<sub>0</sub>      R<sub>8</sub>, R<sub>4</sub>  
       가  
       1      L<sub>0</sub>, H<sub>0</sub>, L<sub>1</sub>, H<sub>1</sub>, L<sub>2</sub>, H<sub>2</sub>, L<sub>3</sub>, H<sub>3</sub>, L<sub>4</sub>, H<sub>4</sub>  
       2      d<sub>0</sub> - d<sub>7</sub>  
       0 - R<sub>8</sub>      L<sub>0</sub>, L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub>, L<sub>4</sub>, H<sub>0</sub>, H<sub>1</sub>, H<sub>2</sub>, H<sub>3</sub>, H<sub>4</sub>  
       R<sub>0</sub> - R<sub>8</sub>      R<sub>4</sub>  
       (112, 114)      R<sub>0</sub> - R<sub>8</sub>  
       d<sub>0</sub>      1      (112-114)  
       (mirror image)      d<sub>0</sub>  
       (200)      L<sub>0</sub>  
       R<sub>5</sub>, (R<sub>2</sub>, R<sub>6</sub>), (R<sub>1</sub>, R<sub>7</sub>), (R<sub>0</sub>, R<sub>8</sub>)      가      (230, 232, 234, 236)      2가  
       (230, 232, 234, 236)      가      16      (most significant bit  
       s)      가      2      '가' - (add-dividers)      2  
       2      16-      가      17-      2      7  
       16      , 1      , 17      , 16  
       2  
       3      1      (240, 242, 244, 246, 248)      (240, 242, 244, 246)  
       가 - (236, 234, 232, 230)      h<sub>1</sub>, h<sub>2</sub>, h<sub>3</sub>, h<sub>4</sub>, 가 -  
       , 2      , 2      가      2      2  
       , h<sub>1</sub> - h<sub>4</sub>      (240-246)      (248)      2h<sub>4</sub> d<sub>4</sub>, 2h<sub>3</sub> d<sub>3</sub>, 2h<sub>2</sub> d<sub>2</sub>, 2h<sub>1</sub> d<sub>1</sub>  
       d<sub>0</sub>      R<sub>4</sub>      가      (250)      가      (250)      가  
       L<sub>0</sub>  

h<sub>0</sub>d<sub>0</sub> + 2h<sub>1</sub>d<sub>1</sub> + 2h<sub>2</sub>d<sub>2</sub> + 2h<sub>3</sub>d<sub>3</sub> + 2h<sub>4</sub>d<sub>4</sub>.

2      3      R<sub>2</sub>      R<sub>4</sub>      H<sub>0</sub>      (222)      가      R<sub>1</sub>      R<sub>5</sub>      가  
       가 - (224)      가      가 - (222)      (222)      2      2      (222, 224, 226)  
       ,      , 2      , 2      , 3      , 2      , 2      , 2      , 2  
       - d<sub>0</sub> d<sub>2</sub>      가 - (222)      가 2      , 2      d<sub>4</sub> d<sub>2</sub>      , 2      d<sub>3</sub> d<sub>1</sub>      , 2  
       - (224)      , 2      , 2      , 2      , 2      , 2      , 2      , 2  
       ,      , 2      , 2      , 2      , 2      , 2      , 2      , 2  
       (251)      R<sub>4</sub>      가      (250, 251)      d<sub>1</sub>      (221)      g<sub>0</sub>      32      가  
       (250)      , 2      , 2      , 2      , 2      , 2      , 2      , 2  
       q      (251)      , 2      , 2      , 2      , 2      , 2      , 2      , 2  
       , 2      , 2      , 2      , 2      , 2      , 2      , 2      , 2  
       (200)      (201)      R<sub>1</sub>      R<sub>0</sub>      d<sub>i</sub>  
       ,      , 2      , 2      , 2      , 2      , 2      , 2  
       4      d<sub>5</sub> d<sub>6</sub>      (201)      R<sub>1</sub> R<sub>0</sub>      2      3

4	d <sub>2</sub>	,	d <sub>1</sub>	2	,	(248)	h <sub>0</sub>	L <sub>1</sub>	H <sub>1</sub>	.	.	R <sub>5</sub>	R <sub>4</sub>
-	가		d <sub>3</sub>	가	-	(246)	2h <sub>1</sub>	가	2	.	.	R <sub>3</sub>	R <sub>2</sub>
-	(232)		R <sub>7</sub>	가	,		2h <sub>1</sub>	가	2	.	.	(244)	d <sub>0</sub>
.		R <sub>1</sub>					d <sub>1</sub>	d <sub>5</sub>	가	,	.	2h <sub>2</sub>	가
.							(242)	2h <sub>3</sub>	가	,	.	(234)	가
.	d <sub>6</sub>	d <sub>2</sub>	가	-		(236)	2h <sub>3</sub>	가	,	.	.	R <sub>0</sub>	R <sub>8</sub>
0)	2h <sub>4</sub>	.				(240, 242, 244, 246, 248)	R <sub>0</sub> - R <sub>8</sub>	가	2	.	.	가	(250)
5, 223, 221)	L <sub>1</sub>	.						가	-	.	.	(226, 224, 222)	(227, 22
5	R <sub>0</sub> - R <sub>8</sub>		R <sub>1</sub>	R <sub>0</sub>			4	2	H <sub>1</sub>	.	.	d <sub>7</sub>	d <sub>6</sub>
		,					h <sub>i</sub>	g <sub>i</sub>	.	.	.	가	2
6	R <sub>0</sub> - R <sub>8</sub>		R1	R <sub>0</sub>				2			.	5	.
,	d <sub>5</sub>	d <sub>4</sub>								.	.	d <sub>7</sub>	.
.	d <sub>7</sub>	가	(20)			(201)	H <sub>0</sub> - H <sub>4</sub>	가	.	.	.	,	.
.	L <sub>0</sub> - L <sub>4</sub>					(200)	L <sub>0</sub> - L <sub>4</sub>	가	.	.	.	L <sub>0</sub> - L <sub>4</sub>	H <sub>0</sub> - H <sub>4</sub>
7	1	.	R <sub>3</sub> - R <sub>0</sub>	L <sub>0</sub> - L <sub>4</sub>	가		R <sub>0</sub> - R <sub>4</sub>	R <sub>4</sub>	.	.	.	R <sub>5</sub> , R <sub>6</sub> , R <sub>7</sub>	2
R <sub>8</sub>	.	L <sub>0</sub> - L <sub>4</sub>	(266)	(260, 262)	.	(201)	L <sub>i</sub>	H <sub>i</sub>	.	.	.	,	.
0)	L <sub>0</sub>	HL <sub>0</sub>	d <sub>i</sub> 가	2	2		LL <sub>1</sub>	HL <sub>1</sub>	.	.	.	1	(20
L <sub>0</sub>	HL <sub>0</sub>	가	(250, 251)	32	32				.	.	.	L	.
40	40	54	,	16	16			DWT	.	.	.	16	.
,			가		16				.	.	.	16	.
1	,								.	.	.	(200)	.
,									.	.	.	(unsigned)	.
,	128	128	,	128	128	,			.	.	.	d <sub>0</sub> - d <sub>4</sub>	.
,	0								.	.	.	-128	127
128	256	256	,	2 <sup>16</sup>	2 <sup>16</sup>	,		2 <sup>16</sup>	256	256	256	16	16
2 <sup>8</sup>	,		,	8					가	1	.	.	(off-t
he-shelf)	.		(260, 262)						.	.	.	.	.
8	L <sub>0</sub> - L <sub>4</sub>	H <sub>0</sub> - H <sub>4</sub>	,	i	'0'				.	.	.	.	(804)
,	(802)	R <sub>0</sub>	R <sub>8</sub>	,	i	1	1	1	.	.	.	,	.
R <sub>0</sub>	,	d <sub>0</sub>	,	i=4	,	i=1	i	i+1	.	.	.	(804)	(806)
,	가	R <sub>0</sub>	R <sub>0</sub>	,	,	,	d <sub>0</sub>	i=4	1	1	.	,	가,
'2'	d <sub>1</sub>	(806)	,	,	,	,	가	R <sub>1</sub>	i=2	i=2	.	,	,
,	(804)	1	,	,	,	,	R <sub>0</sub>	d <sub>2</sub>	,	,	.	,	i
d <sub>3</sub>	d <sub>1</sub>	(806)	가 R <sub>0</sub>	,	R <sub>3</sub>	i가	d <sub>0</sub>	d <sub>2</sub>	,	i가 '3'	,	R <sub>1</sub>	가,
,	,	가 R <sub>0</sub>	,	,	,	'4'가	1	1	,	(804)	.	.	.
,	R <sub>0</sub>	R <sub>0</sub>	,	d <sub>0</sub>	R <sub>3</sub>	d <sub>2</sub>	R <sub>1</sub>	,	'i'가 '1'	d <sub>1</sub>	1	d <sub>1</sub>	'4'
,	,	,	,	,	,	,	,	.	가	1	.	.	R <sub>2</sub>

(57)

1.

N (SB), (data element) N -  
, SB SB ; 1 SB ; 2 SB ; 가 가 ; 1 가 ; 2 가 ;  
N SB ; 1 가 ; ; 1  
N SB ; 2 가 ; ; 2

2.

1 ,  
1 SB SB 1 SB

3

1 , 2 SB SB 2 SB

4

1

5.

1

6.

1 , 9-7

(biorthogonal Spline filter)

7.

$$1 \quad 1 \quad ((N-1)/2)+1 \quad 1 \quad ((N-1)/2)+1$$

8

7 ,  
 1  $(N-1)/2$   $((N-1)/2)+1$   $(N-1)/2$

9.  
 2 ,  
 1  $((N-1)/2)+1$

10.  
 3 ,  
 2  $(N-1)/2$

11.  
 1 ,  
 1 , 1 가 1 가

12.  
 11 ,  
 2 , 2 가 2 가

13.  
 1 ,

14.  
 13 ,

15.

N ,  
 N - ;  
 N 1 가 ;  
 N 2 가 ;

16.  
 15 ,  
 1 가 가

17.  
 16 ,  
 2 가 가

18.  
 15 ,  
 (unsigned) (fixed point fractions)

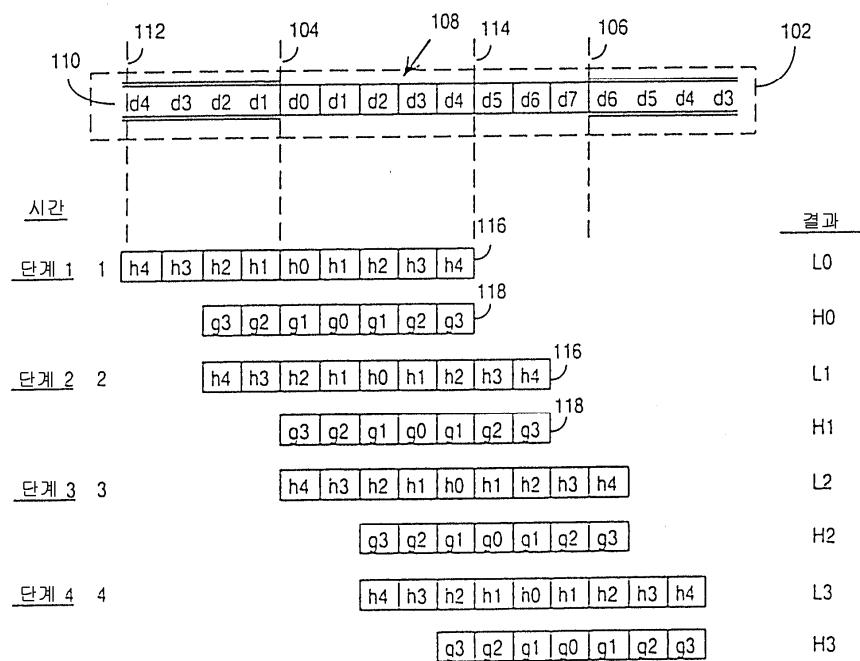
19.  
 18 ,

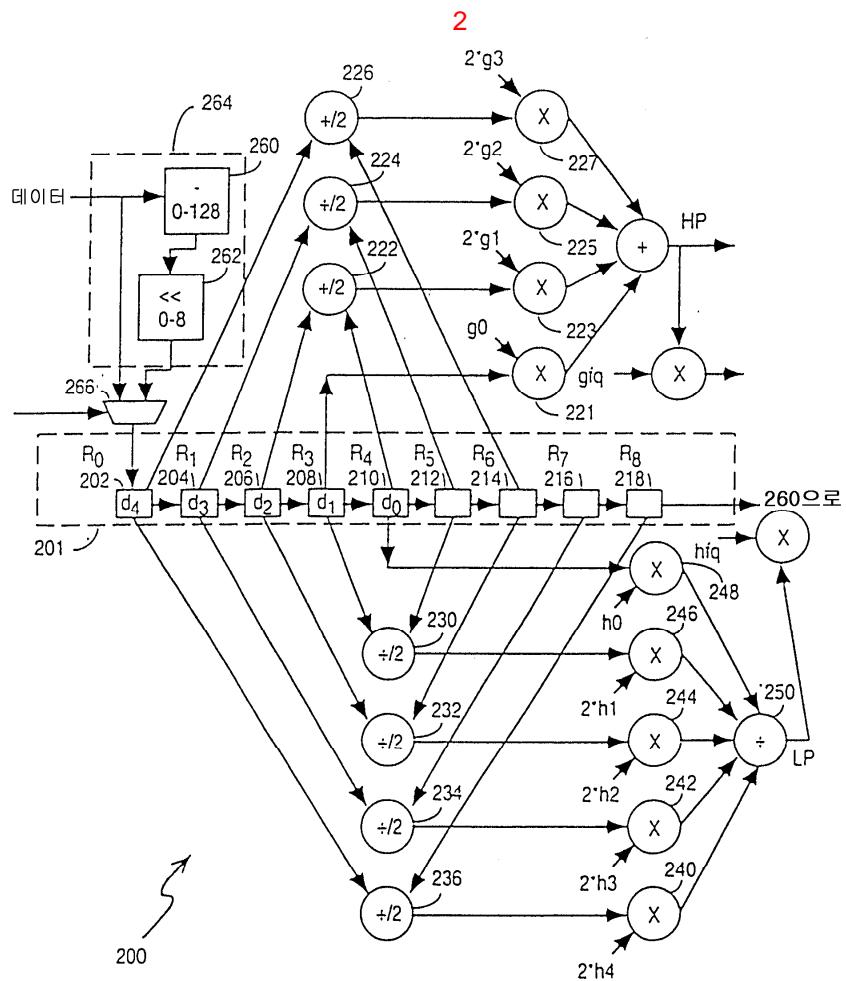
20.  
 19 ,

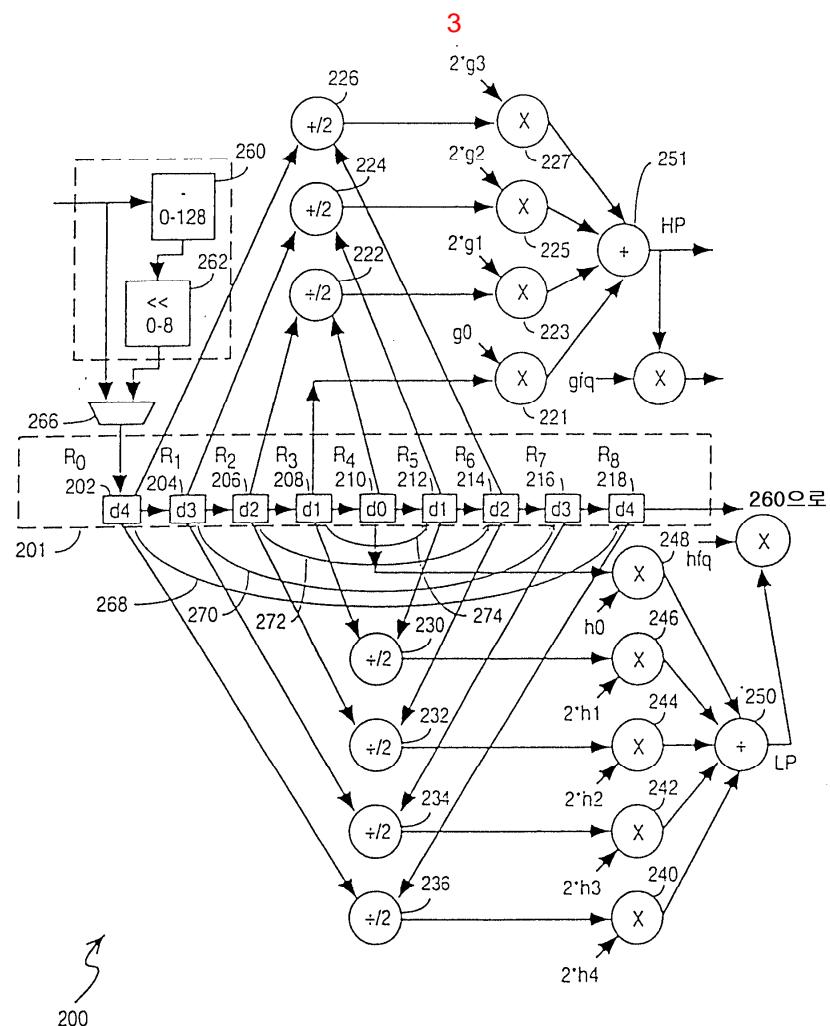
21.

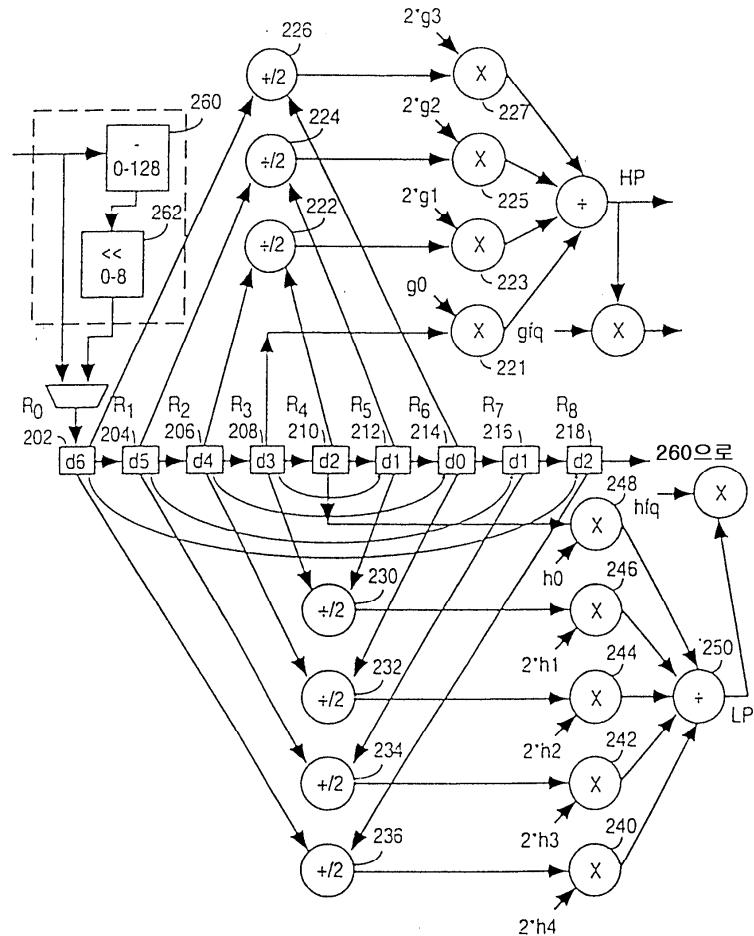
N	(SB)	,	N-	,
N	SB	1 SB	가	1 가
1 가	-	(add-divider)	,	2
N	SB	2 SB	가	2 가
2 가	-	;	,	2
2	1	2	1	;
2	2	2	2	

1

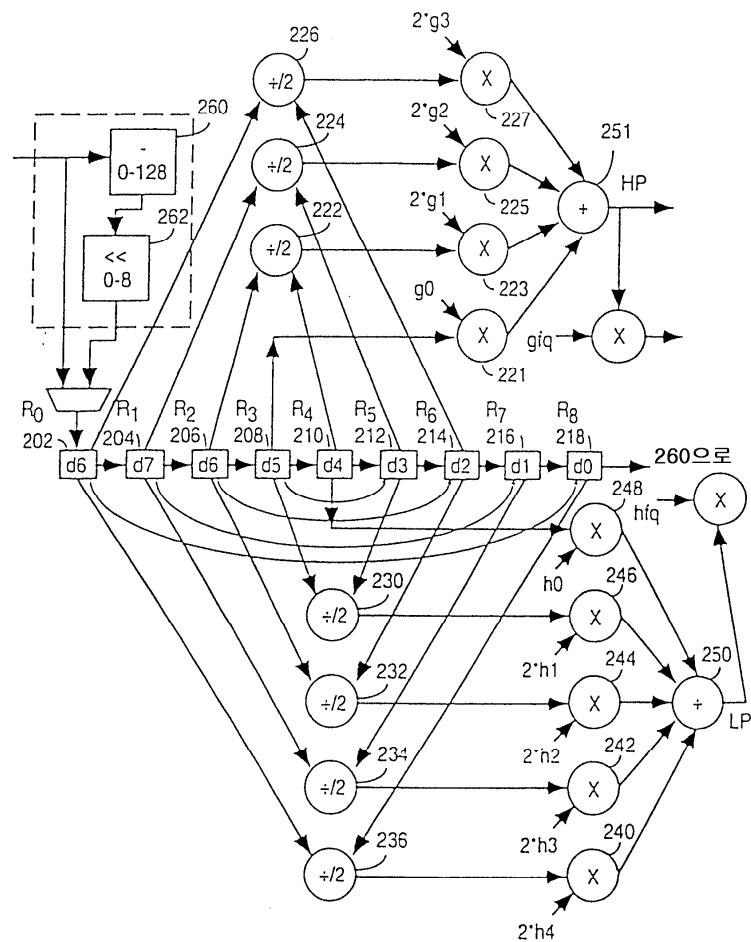








5



6

