

(54)

V L S I

가 . N (SB) ,
N SB N-1 SB 가 1 가 .
가 N SB 2 SB 가 2 가
가 1 가
1 2
2
2
 , DWT
/
 , 가
 (wavelets)
 , DCT(discrete cosine transform) 가
 DWT(Discrete Wavelet Transform)
 DWT (discrete) , DWT VL
SI(Very Large Scale Integrated) , DWT
DWT 2 - 2
- , -
-
 , DWT
VLSI VLSI 가 , DWT DWT
VLSI DWT 100
DWT
 (SB) , N-

1 가 . N SB 1 SB 가
2 가 . 가 , 2 SB 가
가 1 1 가 가
2 2 가 .

[illegible]

'가

DWT (Discrete Wavelet Transform)

9-7

DWT가

DWT -

$$\text{DWT} \quad L = \{L_0, L_1, \dots, L_{N/2-1}\} \quad \text{가} \quad (data\ elements)' \quad d = \{d_0, d_1, \dots, d_{n-1}\} \quad - \\ H = \{H_0, H_1, \dots, H_{N/2-1}\} \quad ,$$

$$L_n = \begin{matrix} h_{2n-k} & d_k \\ h_i & g_i \end{matrix}, H_n = \begin{matrix} g_{2n-k} & d_k \\ g_i & d_i \end{matrix} \quad n=0,1,..N/2-1$$

9-7

DWT

$$h_{-2}, h_{-1}, h_0, h_1, h_2, h_3, h_4) \quad \begin{matrix} .9-7 \\ 7 \end{matrix} \quad - \quad (g_{-3}, g_{-2}, g_{-1}, g_0, g_1, g_2, g_3) \quad \begin{matrix} 9 \\ - \end{matrix} \quad (h_{-4}, h_{-3}, \dots, h_{N/2-1})$$
$$L_0 = h_0 d_0 + 2h_{-1}d_1 + 2h_{-2}d_2 + 2h_{-3}d_3 + 2h_{-4}d_4,$$
$$L_1 = h_2d_0 + h_1d_1 + h_0d_2 + h_{-1}d_3 + h_{-2}d_4 + h_{-3}d_5 + h_{-4}d_6, +h_4d_2 + h_3d_1$$
$$L_2 = h_4 d_0 + h_3 d_1 + h_2 d_2 + h_1 d_3 + h_0 d_4 + h_{-1} d_5 + h_{-2} d_6 + h_{-3} d_7 + h_{-4} d_8$$

L i

가

h i

L i

$$L_0 = h_0(0 + \bar{d}_0) + h_1(\bar{d}_1 + \bar{d}_1) + h_2(\bar{d}_2 + \bar{d}_2) + h_3(\bar{d}_3 + \bar{d}_3) + h_4(\bar{d}_4 + \bar{d}_4),$$
$$L_1 = h_0(0 + d_2) + h_1(d_1 + d_3) + h_2(d_0 + d_4) + h_3(d_1 + d_5) + h_4(d_2 + d_6),$$
$$L_2 = h_0(0 + d_4) + h_1(d_3 + d_5) + h_2(d_2 + d_6) + h_3(d_1 + d_7) + h_4(d_0 + d_8)$$

L i

9-7 $H_n (n = 0, 1, \dots, N/2 - 1)$

$$H_0 = g_0 d_1 + g_1(d_0 + d_2) + g_2(d_1 + d_3) + g_3(d_2 + d_4),$$
$$H_1 = g_0 d_3 + g_1(d_2 + d_4) + g_2(d_1 + d_5) + g_3(d_0 + d_6)$$
H_i

$N/2$, 1 9-7 - - - DWT N- $N/2$ - (significance)

$h_{-i} = h_i$ $g_{-i} = g_i$ 가 1 1 , d_i^2 , , (Nyquist's theory) , N ()

$L_0 = h_0 d_0 + h_1 d_1^2 + h_2 d_2^2 + h_3 d_3^2 + h_4 d_4^2$
 $H_0 = g_0 d_1 + g_1(d_0 + d_2) + g_2(d_1 + d_3) + g_3(d_2 + d_4)$

L , H

$(104, 106)$ $d_0 - d_7$ - (108) (102) 1
 d_1, d_2, d_3, d_4 d_0 d_1, d_2, d_3, d_4 (110) 가 d_0

$16-$ h_0, h_1, h_2, h_3 g_0, g_1, g_2, g_3
 (102) d_i h_i g_i 가 d_i h_i g_i

(102) d_i h_i g_i 가 d_i h_i

$(112, 114)$ 가 h_i

d_i , $h_4 d_4, h_3 d_3, h_2 d_2, h_1 d_1, h_0 d_0, h_1 d_1, h_2 d_2, h_3 d_3$, and $h_4 d_4$,

가 가 , $L_0 = h_0 d_0 + h_1 d_1^2 + h_2 d_2^2 + h_3 d_3^2 + h_4 d_4^2$.

가 가 , g_i d_i

$g_3 d_2, g_2 d_1, g_1 d_0, g_0 d_1, g_1 d_2, g_2 d_3, g_3 d_4$

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

h_i (116) g_i (118) h_i^2 d_i^2

$h_4 d_2, h_3 d_1, h_2 d_0, h_1 d_1, h_0 d_2, h_1 d_3, h_2 d_4, h_3 d_5$ and $h_4 d_6$.

가

$L1 = h_0 d_2 + h_1(d_1 + d_3) + h_2(d_0 + d_4) + h_3(d_1 + d_5) + h_4(d_2 + d_6)$.

H_1 d_i 1 2 2

H_1

$H1 = g_0 d_3 + g_1(d_2 + d_4) + g_2(d_1 + d_5) + g_3(d_0 + d_6)$.

1 가 - (non-causal) ,

2 (200) N (201) N (202, 204, 206, 208, 210, 212, 214, 216, 218)

d_i 16- d_i 16- R_i d_0, d_1, d_2 R

R_i . (264)
 $d_0 - d_4$ 가 (264)
 $d_0 - d_4$ (260, 262) (266) . 1 4 1 (264)
 $d_0 - d_4$ (266) (260, 262) . (266)
 $d_0 - d_4$ R_0, R_1, R_2, R_3, R_4
 R_0, R_1, R_2, R_3, R_4 d_0, d_1, d_2, d_3, d_4 d_0, d_1, d_2, d_3, d_4 d_0, d_1, d_2, d_3, d_4 (200)
 $d_0 - d_4$ 가 $R_4 - R_0$,
 d_4, d_3, d_2, d_1 , (268, 270, 272, 274)
 R_5, R_6, R_7, R_8 , d_1, R_3, R_5, d_2
 $R_2, R_6, d_3, R_1, R_7, d_4, R_0, R_8, R_4$.
 (200) ,
 $L_0, H_0, L_1, H_1, L_2, H_2, L_3, H_3, L_4, H_4$,
 $d_0 - d_7$, $L_0, L_1, L_2, L_3, L_4, H_0, H_1, H_2, H_3, H_4$ $R_0 - R_8$
 $R_0 - R_8$.
 $(112, 114)$ d_0 , d_0 4 . 1 , (112-114)
 $(112, 114)$ d_0 ,
 (200) L_0 .
 $R_5), (R_2, R_6), (R_1, R_7), (R_0, R_8)$ (230, 232, 234, 236) 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-
 $16, 1$, 17 16
 2 .
 3 가 - (240, 242, 244, 246, 248) . (240, 242, 244, 246)
 $(236, 234, 232, 230)$. h_1, h_2, h_3, h_4 , 가 -
 $h_1 - h_4$ 가 가 2 가 2 .
 $(240-246)$ $2h_4 d_4, 2h_3 d_3, 2h_2 d_2, 2h_1 d_1$.
 d_0, R_4 (248) h_0 (248, 246, 242, 240)
 $가$ 가 (250) . 가 (250) 가
 1 L_0 .
 $h_0 d_0 + 2h_1 d_1 + 2h_2 d_2 + 2h_3 d_3 + 2h_4 d_4$.
 $2, 3$ H_0 . 가 .
 R_2, R_4 가 - (222) 가 . R_1, R_5 가
 (224) 가 . R_0, R_6 가 가 - (226) 가
 $가$ 가 -
 2 가 , 가 - (222, 224, 22
6) 가 2 . 3
 d_0, d_2 가 - (222) 가 , 가 가 2
 (224) 가 , 가 가 2 . d_4, d_2 가 - (226) 가
 $가$ 가 2 .
 $(227, 225, 223)$ $2g_3, 2g_2, 2g_1$.
 R_4 가 . d_1 (221) g_0 , 가 가
 (251) 가 . 가 (250, 251) 가 32 . , 가
 (250) 가 hfq , (251) 가 gfq . gfq hf
q
 (200) d_i .
 4 , 가 (201) 2 3 .
 d_5, d_6 R_1, R_0 .

4 d_2 , d_1 , d_3 가 (248) h_0 L_1 H_1 R_5 R_3 R_4
 가 (232) R_7 R_1 (246) $2h_1$ (230) 가 R_2 R_6 d_4 d_0 가
 - R_7 R_1 (242) $2h_3$ (234) 가 R_0 R_8 (244) $2h_2$ 가
 0) d_6 d_2 가 - (236) 가 가 2 (250) 가 (24
 L_1 (240, 242, 244, 246, 248) $R_0 - R_8$ 가 - (226, 224, 222) (227, 22
 5, 223, 221) $R_0 - R_8$ R_1 R_0 2 d_7 d_6
 5 h_i g_i 가 (250, 251) 가
 6 $R_0 - R_8$ 2 5 d_7
 d_5 d_4 R_1 R_0 d_7
 , d_7 가 (20) (201) , 가 , $L_0 - L_4$ $H_0 - H_4$
 $L_0 - L_4$ (200) $L_0 - L_4$ 가 $R_0 - R_4$ 2 R_5, R_6, R_7 ,
 7 1 $R_3 - R_0$ $L_0 - L_4$ (260, 262) R_4 $L_0 - L_4$ (20
 R_8 $L_0 - L_4$ (266) (201) L_i H_i 2 1 L
 0) HL_0 d_i 가 2 2 LL_1 HL_1 . 2 1
 L_0 HL_0 가 (250, 251) 2 32 . 32 가
 40 54 16 DWT 16 가
 , 가 16 가 16 , 가 -
 1 , (200) (unsigned) $d_0 - d_4$
 , (260) 16 $d_0 - d_4$
 , 128 , -128 127 ,
 , 0 128 가 , 256 , 16
 128 256 2¹⁶ 2¹⁶ 256 16
 2⁸ , 8 가 (off-t
 (260, 262) 1
 he-shelf) $L_0 - L_4$ $H_0 - H_4$ i '0' (804)
 8 (802) R_0 R_8 가 1 , (806)
 R_0 , d_0 , i $i+1$, (804) 가 ,
 , $i=4$, $i=1$, (804) 1 , i
 , d_1 R_0 , d_0 R_1 , i
 , '2' (806) , $i=4$, i 가 2 ,
 (804) 1 , R_0 d_2 , R_1
 d_1 (806) , R_3 , i 가 '3' 가 ,
 가 R_0 , '4'가 (804)
 d_3 , R_0 , d_2 R_1 , '1'가 '1' d_1 R_2
 , d_0 R_3 , '1'가 '1' 가 '4'

0 R₈ (806) '1' , i=4 R₀ d_i (814) d₄ R₄

d₀ 3 L₀ H₀

(816) R₀ d_{i+1} d₅ (816) '1'

6 L₁ H₁ R₀ d_{i+2} d

(816) (818) '1'

R₀ d_{i+3} R₀ d₇ d_{i+2} d₆

'1'

L₂ H₂ (820) '1'

R₀ d_{i+1} d_i L₃ H₃ R₀

'1'

가

(57)

1.

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

2.

1, SB SB 1 SB

3.

1, 2 SB SB 2 SB

4.

1 ,

5.

1 ,

6.

1, 9-7 (biorthogonal Spline filter)

7.

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

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	N	1	가 ;
N	N	2	가 ;
	1	가	
	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 2

1 가 - (add-divider) ;

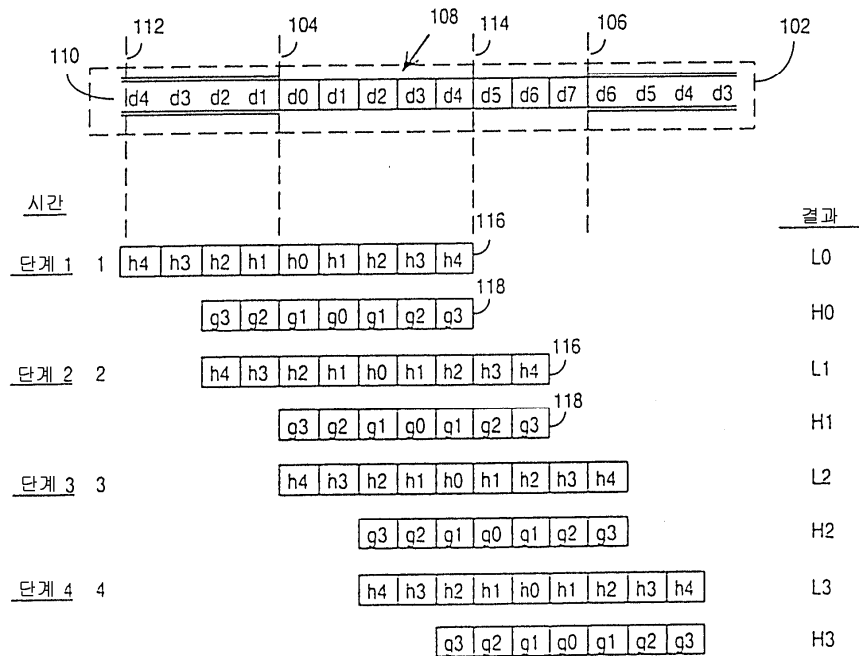
N SB 2 SB 가 , 2 가 2

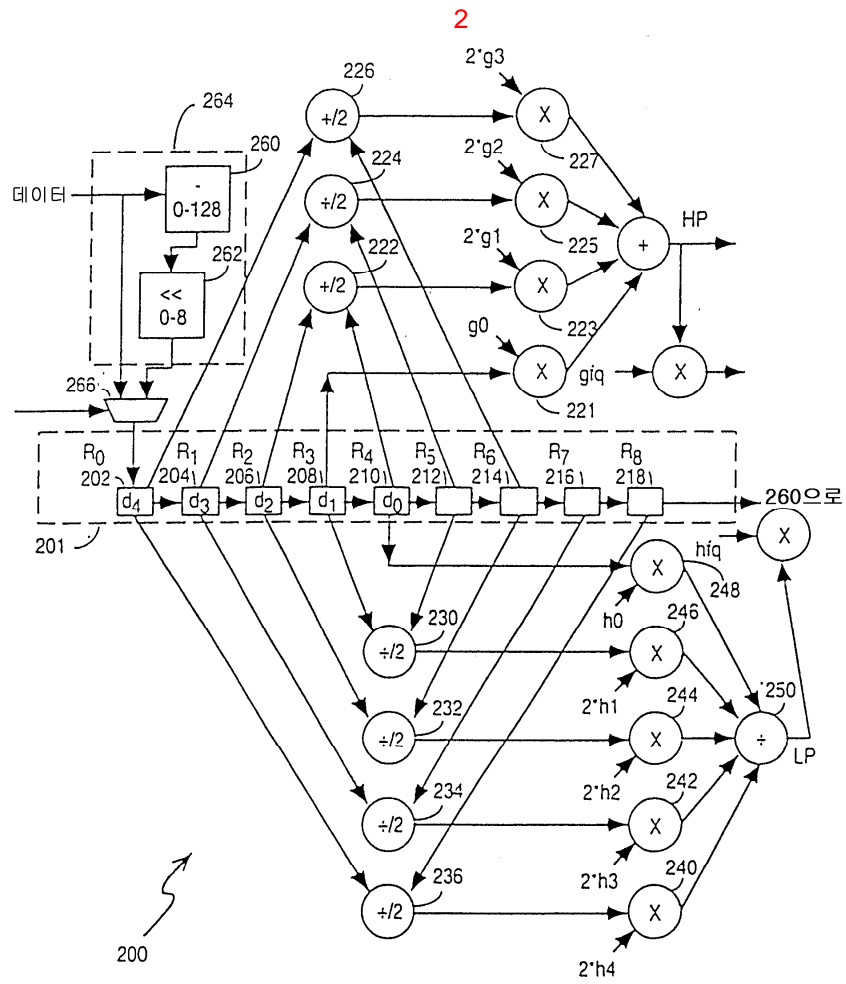
2 가 - ;

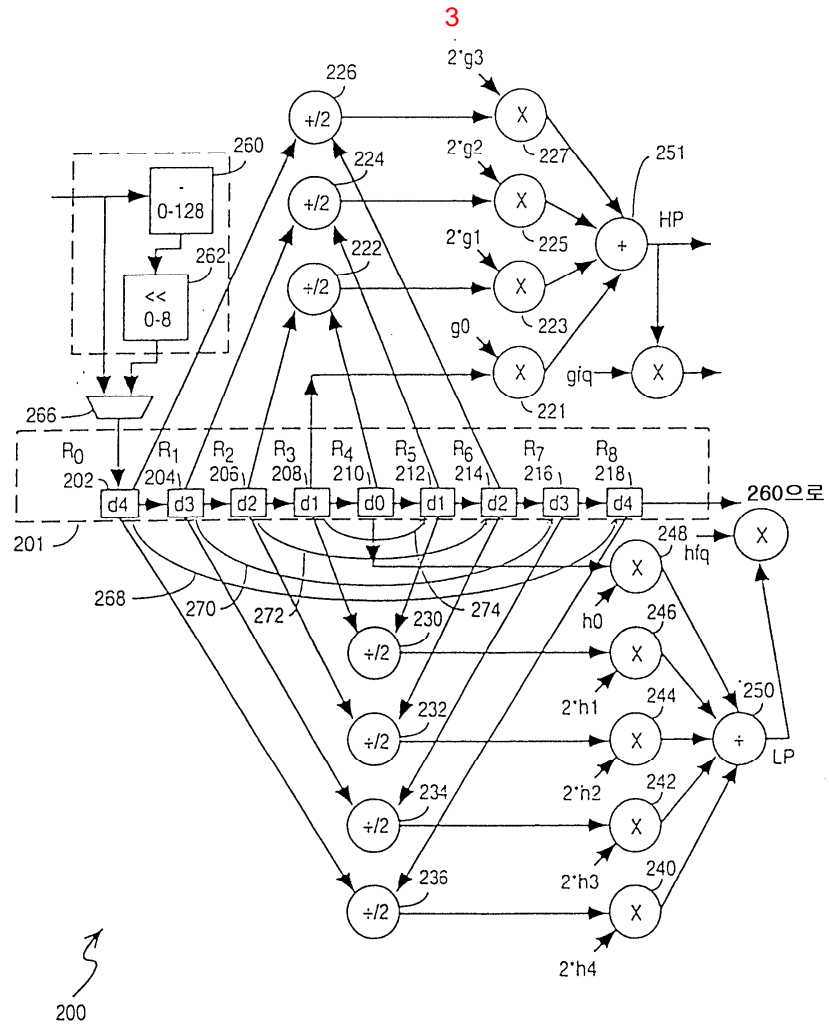
2 1 2 1 ;

2 2 2 2

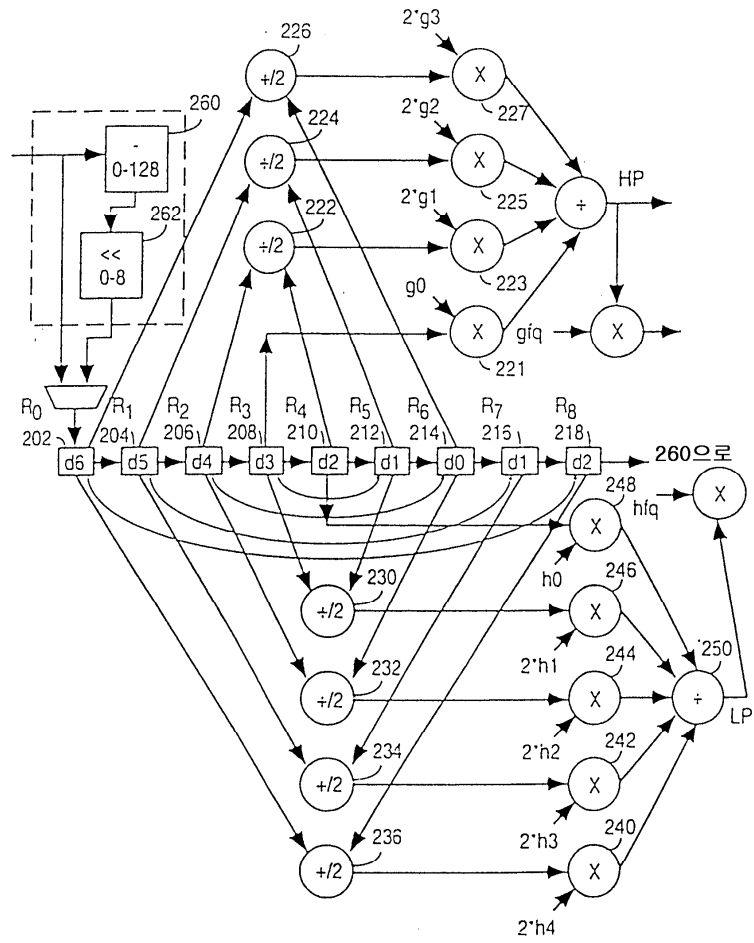
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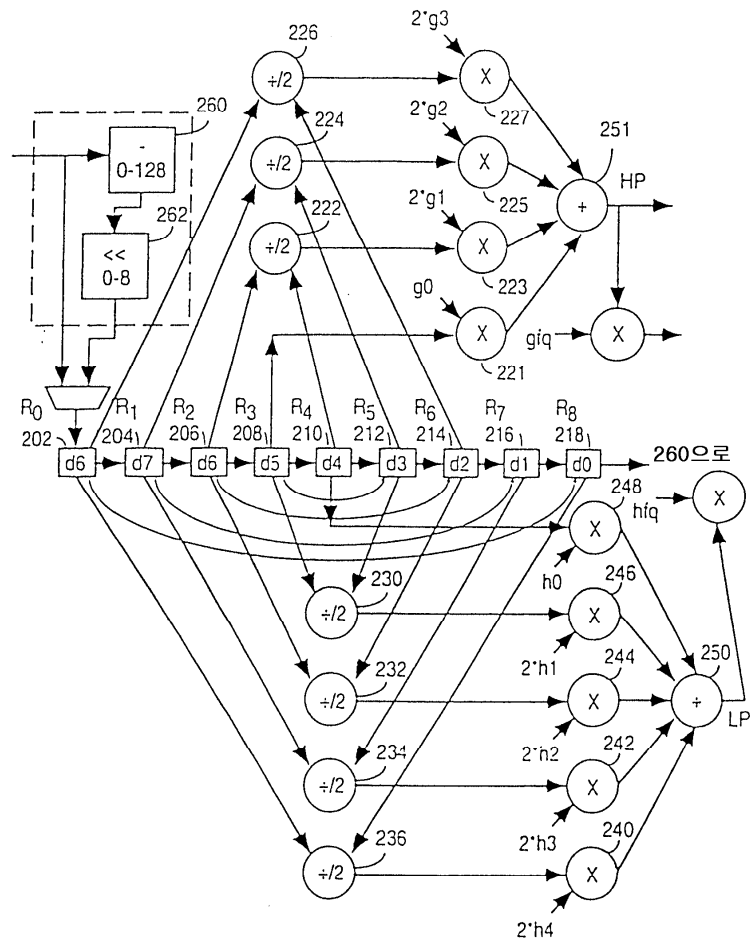




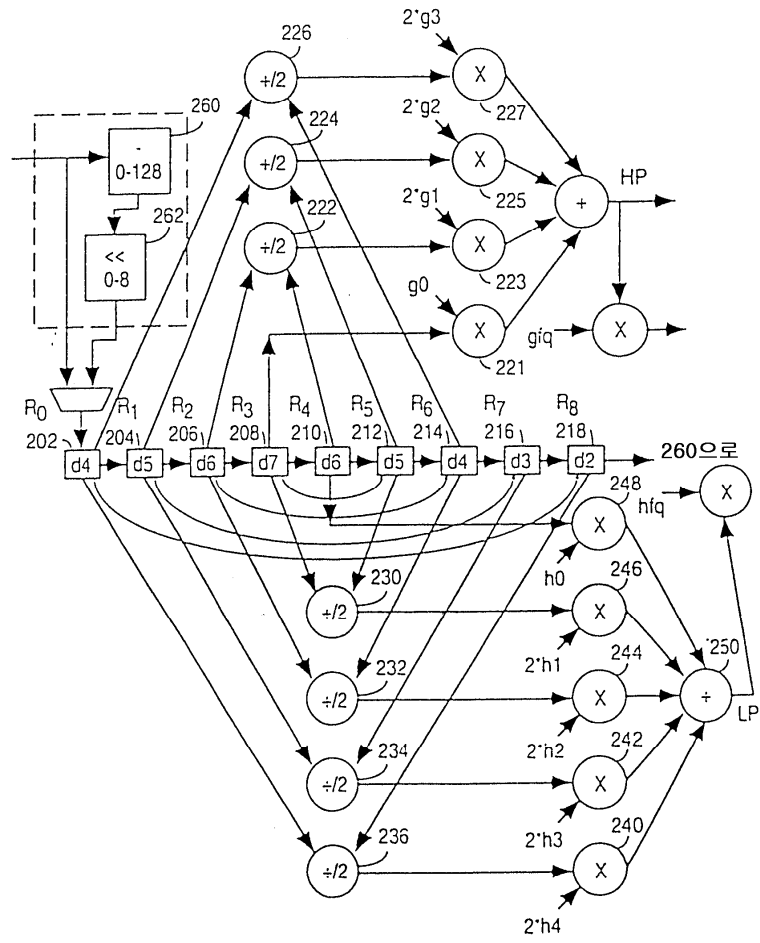
4



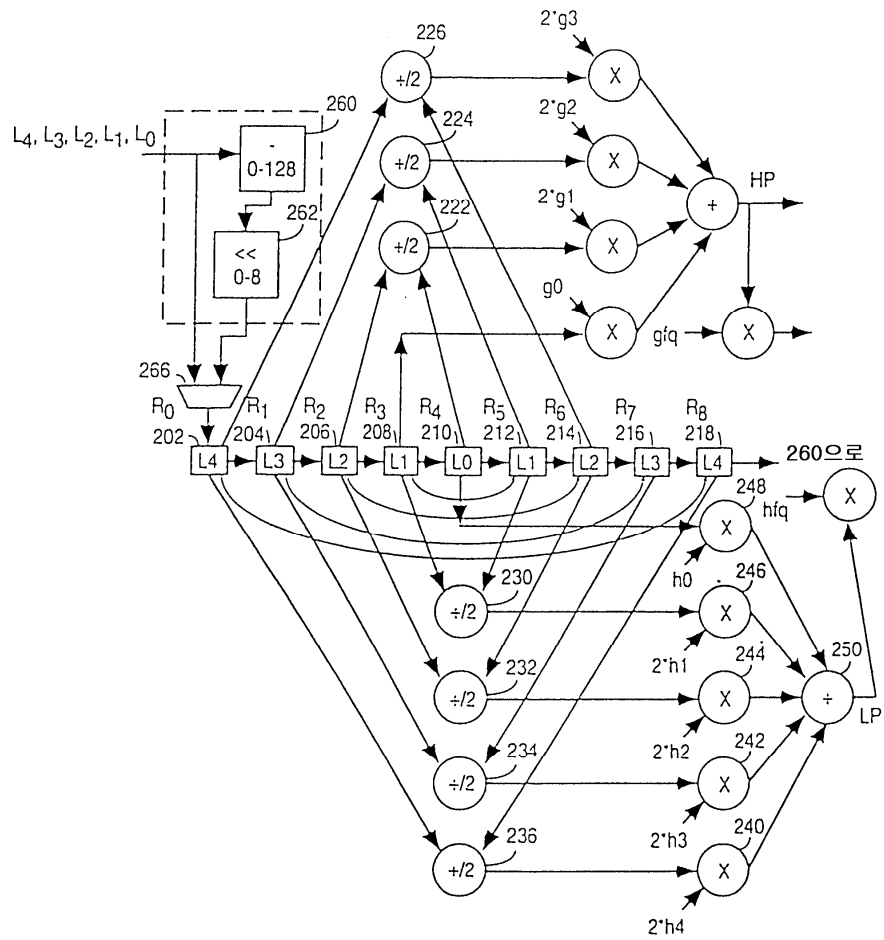
5



6



7



8

