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(73) 가 가 가 가 6 7 35

(72) 가 가 6 7 - 35 가 가
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(74)

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(54)

SN

(11) 가 가 , (15)
, (16) , (19), (20)
(23) , (20) (21)

SN

가

가

」 (Speech Enhancement Using a Soft - Decision Noise Suppression Filter, R.J.McAulay, H.L.Malpass, IEEE Trans. Acoust.,Speech Signal Processing, Vol.28, pp,137 - 145, April 1980)

」 (Frequency Domain Noise Suppression Approach in Mobile Telephone Systems, J.Yang, IEEE ICASSP, Vol.II, pp.363 - 366, April 1993)

SNR()

가

SNR

SNR

가

가

SNR

가

가

SN

(median)

$$RMS_{th} = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} x[k]^2}$$

$$RMS_{th} = \sqrt{\frac{1}{N} \sum_{k=0}^{N-1} y[k]^2}$$

$$SNR_{th} = \frac{RMS_{speech}}{RMS_{noise}}$$

$$dB_{rel} = 10 \log_{10}(SNR_{th})$$

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(11) $y[k]$ (speech) 가 FS 가 FL
 (12) $y[k]$ (noise) 가 FS 가 FL
 (13) $y[k]$ (window) 가 FS 가 FL

(11) $y[k]$ (speech) 가 FS 가 FL
 (12) $y[k]$ (noise) 가 FS 가 FL
 (13) $y[k]$ (window) 가 FS 가 FL

$$W_{input}[j] = \left(\frac{1}{2} - \frac{1}{2} \cdot \cos\left(\frac{2 \cdot \pi \cdot j}{FL}\right) \right)^{\frac{1}{4}} \quad 0 \leq j \leq FL \dots (1)$$

$$W_{output}[j] = \left(\frac{1}{2} - \frac{1}{2} \cos\left(\frac{2 \cdot \pi \cdot j}{FL}\right) \right)^{\frac{3}{4}} \quad 0 \leq j \leq FL \quad \dots(2)$$

FS 8000Hz = 8kHz, FI 80
 10ms, FL 160, 20ms
 FFT (13) 256, FFT 가
 (14) 18, 1

< 1 >

밴드 번호	주파수 범위
0	0~125Hz
1	125~250Hz
2	250~375Hz
3	375~563Hz
4	563~750Hz
5	750~938Hz
6	938~1125Hz
7	1125~1313Hz
8	1313~1563Hz
9	1563~1813Hz
10	1813~2063Hz
11	2063~2313Hz
12	2313~2563Hz
13	2563~2813Hz
14	2813~3063Hz
15	3063~3375Hz
16	3375~3688Hz
17	3688~4000Hz

FFT

(15) y[k]

2

3

A) (11) y[k] RMS((15A) , Root Mean Square) (15)
 (15B), RMS (15C), RMS (15D) (15E)
 (15D) (15E) (15B), RMS (15C)

RMS (15A) RMS k RMS RMS
 [k]

$$RMS[k] = \sqrt{\frac{1}{FL} \cdot \sum_{t=1}^{FL} y^2[t]} \quad \dots(3)$$

(15B) $dB_{rel} [k] = 10 \log_{10} \left(\frac{E_{decay}[k]}{E[k]} \right)$ (4) k (4)

$$dB_{rel} [k] = 10 \log_{10} \left(\frac{E_{decay}[k]}{E[k]} \right) \quad \dots(4)$$

$$E[k] = \sum_{t=1}^{FL} y^2[t] \quad \dots(5)$$

$$E_{decay}[k] = \max \left(E[k], e^{\frac{-FL}{0.65 \cdot FS}} E_{decay}[k-1] \right) \quad \dots(6)$$

(5) $FL \cdot (RMS[k])^2$ (15A) (3) RMS (15A) RMS[k]
 , RMS (15A) (5)
 (15B) (6) () 0.65sec

RMS (15C) $E_{decay} [k]$ 3
 (short term) 가 (long term) RMS
 RMS

$$RMS \quad MinNoise_{short} \quad (7)$$

$$MinNoise_{short} [k] = \min(RMS[k], \max(\alpha(k) e^{\frac{-FL}{0.8 \cdot FS}} MinNoise_{short} [k-1], MinNoise_{short} [k-1] + 5.0 \cdot \alpha(k))) \quad \dots(7)$$

$$\alpha(k) = \begin{cases} 1 & RMS[k] < MAX_NOISE_RMS \text{ 이고} \\ & RMS[k] < 3 \cdot MinNoise_{short} [k-1] \\ 0 & \text{상기이외} \end{cases}$$

가 RMS $MinNoise_{short}$ (speech)

long
g

0.6

1.8

19dB

19dB

1.8

MinNoise_{long} > MinNoise_{short}

MinNoise_{short}

MinNoise_{long}

0.6

1.8

19dB

19dB

1.8

MinNoise_{long} > MinNoise_{short}

MinNoise_{short}

MinNoise_{long}

SNR

rt

(15D)

(8)

RMS

RMS

SNR(SN)

RMS

RMS

MaxSignal_{short}

$$MaxSignal_{short}[k] = \max \left(RMS[k], e^{-\frac{F1}{3.2 \cdot FS}} \cdot MaxSignal_{short}[k-1] \right) \dots (8)$$

ort

0.8

0.4

0.4

MaxSignal_{short}

MaxSignal_{long}

MaxSignal_{short}

MaxSignal_{long}

MaxSignal_{short}

MaxSignal_{long}

(0.7 · MaxSignal_{short} + 0.3 · MaxSignal_{long})

4

RMS

RMS[k],

4

MinNoise_{short}

MaxSignal_{short}

RMS

MinNoise[k]

RMS

MinNoise[k]

RMS

MaxSignal[k]

RMS

MaxSignal[k]

MinNoise_{long}

MaxSignal_{long}

RMS

MaxSignal_{short}

RMS

MinNoise_{short}

SNR

가

가

SNR

MaxSNR

(9)

$$MaxSNR[k] = 20.0 \cdot \log_{10} \left(\frac{\max(1000.0, MaxSignal_{short}[k])}{\max(0.5, MinNoise_{short}[k])} - 1.0 \right) \dots (9)$$

MaxSNR

NS_level

가

0

1

NR_level

$$NR_level[k] = \begin{cases} \left(\frac{1}{2} + \frac{1}{2} \cos \left(\pi \cdot \frac{MaxSNR[k] - 30}{20} \right) \right) \times \\ (1 - 0.002(MaxSNR[k] - 30)^2) & 30 < MaxSNR[k] \leq 50 \\ 0.0 & MaxSNR[k] > 50 \\ 1.0 & \text{상기이외} \end{cases} \dots (10)$$

$$S'[w, k] = \max(S'[w, k], S'[w, k-1] \cdot \text{decay_rate}) \quad (14)$$

$$\text{decay_rate} = e^{\frac{-F1}{(1-0.5 \cdot \text{nr_level}) \cdot FS}} \quad \dots(14)$$

$$SNR[w, k] = 20 \cdot \log_{10} \left(\frac{0.2 \cdot S[w-1, k] + 0.6 \cdot S[w, k] + 0.2 \cdot S[w+1, k]}{0.2 \cdot N[w+1, k] + 0.6 \cdot N[w, k] + 0.2 \cdot N[w-1, k]} \right) \quad (15)$$

$$\text{Pr(Sp)} = 0.5 + 0.45 \cdot (1.0 - \text{NR_level}) \quad (16)$$

$$\text{Pr}(H1 | Y)[w, k] = \frac{\text{Pr}(H1) \cdot p(Y | H1)}{\text{Pr}(H1) \cdot p(Y | H1) + \text{Pr}(H0) \cdot p(Y | H0)} \quad (17)$$

(Bayes Rule)

$$p(Y | H0) = \frac{2 \cdot Y}{\sigma} \cdot e^{-\frac{Y^2}{\sigma}} \quad (18)$$

(Rayleigh pdf)

$$p(Y | H1) = \frac{2 \cdot Y}{\sigma} \cdot e^{-\frac{Y^2 + S^2}{\sigma}} \cdot J_0\left(\frac{2 \cdot S \cdot Y}{\sigma}\right) \quad (19)$$

(Rician pdf)

$$I_0(x) = \frac{1}{2\pi} \int_0^{2\pi} e^{\text{Re}(e^{-j\theta})} d\theta \quad (20)$$

(Modified Bessel function of 1st kind)

(17) (20) H_0 , $y(t)$ 가 $n(t)$, H_1 ,
 $y(t)$ 가 $s(t)$, $n(t)$, $S(t) = 0$, W ,
 k , Y , $Y[w, k]$, S , $S[w, k]$,
 $2 N[w, k]^2$.

(17) $\Pr(H_1 | Y)[w, k]$, (17) $p(Y | H_0)$ (18) , $p(Y | H_1)$ (19)
 , (20) $\log(|X|)$.

(21)

$$I_0(|x|) = \begin{cases} \frac{1}{\sqrt{2\pi|x|}} \cdot e^{x^2 + 0.07} & |x| \geq 0.5 \\ 1 & \text{상기이외} \end{cases} \dots (21)$$

$S[w, k]$ $\Pr(H_1 | Y)$ SN (SNR=5)
 $p(Y | H_1)$ (22)

$$p(Y | H_1) = \frac{2}{\sigma} \cdot e^{-\frac{Y^2}{\sigma} - SNR^2} \cdot I_0\left(2 \cdot SNR \cdot \frac{Y}{\sqrt{\sigma}}\right) \dots (22)$$

$p(Y | H_1)$ SN SNR 가 , SN

SNR , , SN

가 SN $SNR_{new}[w, k]$, SN $p(Y | H_1)$
 $SNR_{new}[w, k]$ (23) . (23) MIN_SNR (24)

$$SNR_{new}[w, k] = \max(MIN_SNR(SNR[w, k]), \frac{S'[w, k]}{N[w, k]}) \dots (23)$$

$$MIN_SNR(x) = \begin{cases} 3 & x < 10 \\ 3 - \frac{x-10}{35} \cdot 1.5 & 10 \leq x \leq 45 \\ 1.5 & \text{상기이외} \end{cases} \dots (24)$$

$SNR_{new}[w, k]$ 가 k SNR . $SNR_{new}[w, k]$
 SN 1.5 , SNR
 가 , SNR 3

(14) $H[w, k]$ (19) $Y[w, k]$ (15) $H[w, k]$ (19) $N[w, k]$

$$H[w, k] = \begin{cases} a + (1-a) \cdot \frac{(Y^2 - N^2)^{\frac{1}{2}}}{Y} & Y > 0 \text{ and } Y \geq N \dots(25) \\ a & \text{상기이외} \end{cases}$$

$\text{SNR} = 0.7 - 0.4 \cdot \text{NR_level}[k]$

(25) SNR 가 $1/2$ SNR

(20) $H[w, k]$ (26) $\text{Pr}(H1 | Y)$ (20) $H[w, k]$ (19) $\text{Pr}(Sp | Y)$

$$H[w, k] \leftarrow \text{Pr}(H1 | Y)[w, k] \cdot H[w, k] + (1 - \text{Pr}(H1 | Y)[w, k]) \cdot \text{MIN_GAIN}$$

...(26)

(26) MIN_GAIN , $0.1 - 15\text{dB}$

(20) $H[w, k]$ (21) $H[w, k]$ 가 $H[w, k]$ (環狀)
 가 (aliasing) 가

$H[w, k]$ () (27), (28) 18

Step1 : $H1[w, k] = \max(\text{median}(H[w-1, k], H[w, k], H[w+1, k]), H[w, k]) \dots(27)$

단, $w-1$ 또는 $w+1$ 이 존재하지 않을 때에는 $H1[w, k] = H[w, k]$

Step2 : $H2[w, k] = \min(\text{median}(H[w-1, k], H1[w, k], H1[w+1, k]), H1[w, k]) \dots(28)$

단, $w-1$ 또는 $w+1$ 이 존재하지 않을 때에는 $H2[w, k] = H1[w, k]$

$$H_{t_smooth} [w,k] \begin{matrix} (22) \\ 128 \\ , 18 \\ 64 \end{matrix} \quad H_{128} [w,k] \begin{matrix} (21) \\ , 64 \\ 128 \\ 18 \end{matrix}$$

$$H_{128} [w,k] \begin{matrix} (23) \\ \text{FFT} \\ (13) \\ \text{FFT} \end{matrix}$$

$$\text{IFFT} \begin{matrix} (24) \\ (23) \\ \text{IFFT} \end{matrix}$$

$$\text{가} \begin{matrix} (25) \\ \text{IFFT} \\ (26) \end{matrix} \quad \text{가}$$

$$\begin{matrix} (21) \\ (15) \end{matrix}$$

SN

SN

가

가

, SN 가

S RMS th th_1 th_1 RM

(57)

1.

likelihood filter) SN (

2.

1 , , .

3.

1 , , .

4.

1 , , .

5.

1 MS(,) Th_1 , Th_1 th R
RMS
RMS

6.

5 , Th_1 th , RMS th
RMS

7.

6 , SN Th_2 .

8.

SN , ,

9.

8 , , .

10.

9 , ,

;

11.

9

12.

Th₁

RMS() , RMS

Th₁ , th ,

RMS
RMS th

13.

12

Th₁

th ,
RMS

RMS

th

14.

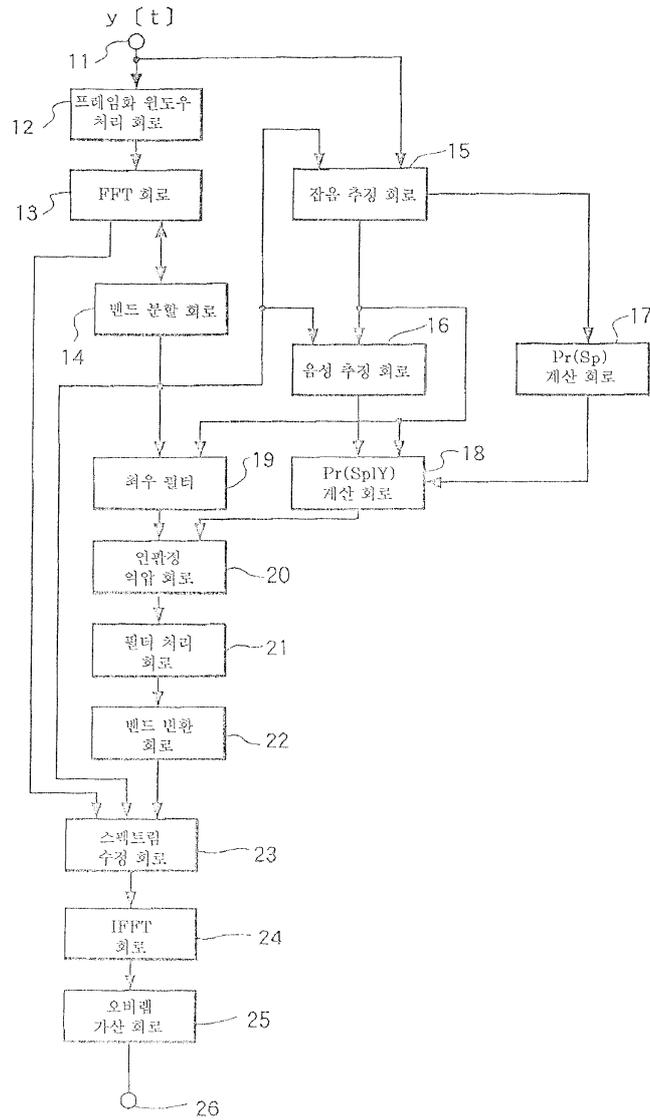
13

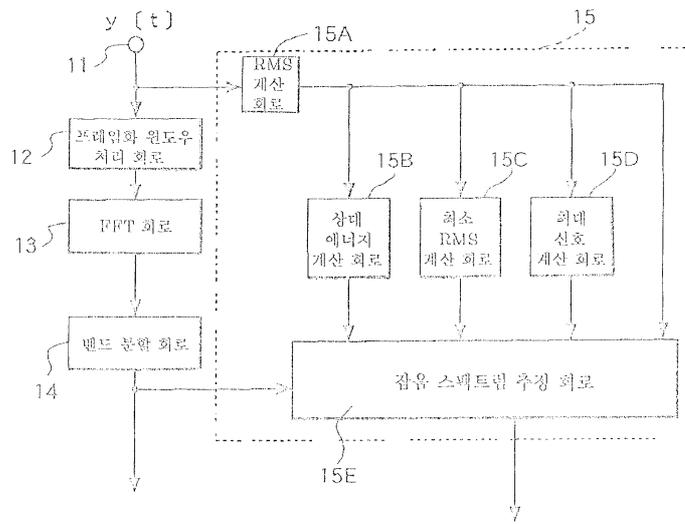
RMS

SN
Th₁

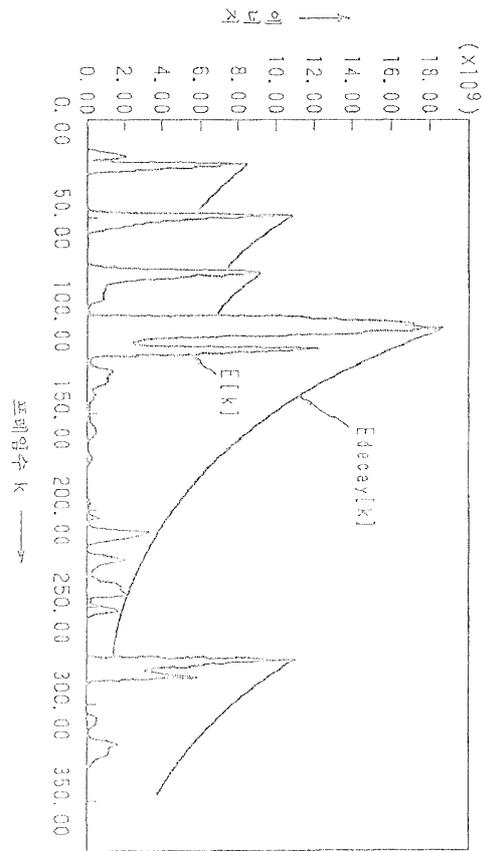
Th₂

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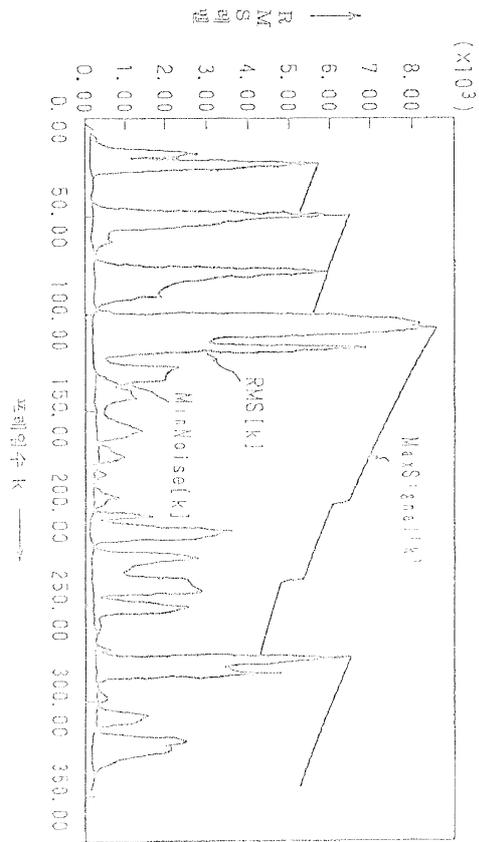




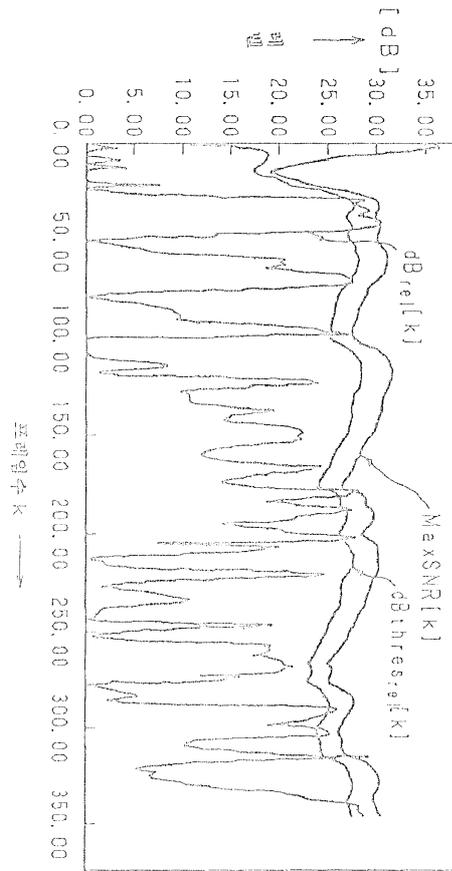
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4



5



6

