B4 6H O@ J8

>v$_9~$_7W; ;Kh$k
3D %5%&%s%I$N@8@.

;a L> !' HDAR=$
3X@RHV9f !' 2170930016-1
;XF3 65 0w !' ;3:j>!90 65<x
Ds =P F| !' 1998 G/2 7n20 F|

N)L?4 [Bg3X M}9)3XIt >pJs3X2J

FbMF9<35

%9%F%l%*%5%&%s%I$O!"#2$D$N%9%T!<%+$r8GDjE*$KG[CV$9k?$a<u2;<T$N0LCV$,8GDj$5lk$H$$$&7gE@$,$"$k!#$3$N7gE@$r2r>C9k$?$a!"3D %5%&%s%I@8@.5;=Q$KCmL\$7!"3D %5%&%s%I@8@.$r<B8=$r;n$_$?!#

K\O@J8GO!"3D %5%&%s%I$N@8@.5;=Q$+$i6qBNE*$J@8@.J}K!$^$G@bL@$7!"=>Mh$N%9%F%l%*%5%&%s%IHO0[Jk3D %5%&%s%I@8@.%7%9%F%`$N9=C[$K$D$$$F=RYk!#

K\8&5fGO3D %5%&%s%I@8@.%7%9%F%`$r%Q!<%=%J%k%3%s%T%e!<%?>e$G<B8=$9$k$b$N$G$"$k!#%7%9%F%`9=@.H7$F!"F~=PNOIt$H%G!<%?7W;;ItHBg-$/J,$1!"%G!<%?7W;;ItNCfK$O!"FFT It$H>v$_9~$_=hM}It$HJ,$1$F$$$k!#3liN=hM}ItOOMicroSoft <R$NVisualC++$rMQ$$$F:n@.7?!#$^$?%7%9%F%`KhCF@8@.5l$?3D %5%&%s%I$r2;@<2r@O%=%U$rMQ$$$FI>2A$r9T$C$?!#

L\<!

1 O8aK

6aG/, =>Mh$N%9%F%l%*:F@8$H$O0[$J$k 3D %5%&%s%I:F@85;=Q$KBP9k4X?4$,Hs>o$K9b$^$CF-$F$$$k!#3l$O%^%k%A%a%G%#%";~Be$NE~Mh$,0lHLE*$KG'CN5l!"%^%k%A%a%G%#%";~Be$r;Y$($k5;=Q$NH/E8$,K>$^lF$-$F$$$k$+$iG"$k!#$3Nh$&$J>u67NCfG2>A[8=<B(virtual reality) $N<B8=$d5!3#$H?M4V$H$N%$%s%?!<%U%'!<%9$N8~>e$JIN$?$a$K!"D03P>pJs$O;k3P>pJsHJBsG=$NLr3d$,=EMWHJCF$-$F$$$k!#

3D %5%&%s%I$O2;A|Dj0L$H8FPl$k5;=Q$KhC$F@8@.$5lkbNG"$k!#2;A|Dj0L$H$O!"D0<h<T$,J|<M5l$?$H$-2;A|$rCN3P$7!"$=$N2;A|$NOLCV!5JwN%!"J}8~!K$rH=CG$9k3HG$"$k!#2;A|Dj0L$rD0<h<T$,CN3P9k<jCJH7$F!"%X%C%I%[%s:F@87O$H%9%T!<%+:F@87O$,$"$k!#$=l>lN:F@87OKD$$$F=>Mh$N%9%F%l%*86M}$rbH$K0c$$$r0J2<$K<($9!#

%X%C%I%[%s:F@8GOD03PHN4X78$,M}2r$7d9$$$?$a!"M}A[E*$J2;A|$,Dj0L$G$-$k$H$$$&3H$,D9=j$H7F5s2ilk!#7+$7!"%X%C%I%[%s$rIU1k3HKhCF!":F@8G-$k>l=j$,8BilF7$^$&$H$$$&3H$H!"F,It$H0l=o$KF0$$$F7^$&$?$a!"4i$N8~$-$,JQol$PF1$8h&$K2;A|$b0\F0$7$F7^$&$H$$$&#2DN7gE@$,$"$k!#<!$K!"%9%T!<%+!<:F@8GO0lHLE*$J4D6-$G:F@8G-kH$$$&D9=j$,$"k,!"%9%T!<%+$r8GDjE*$KG[CV9k3H$,B?$/!"%9%T!<%+%7%9%F%`$NCf1{$GM}A[E*$J2;A|$rDj0L9k$?$a!"D0<h<T$NOLCV$,8GDj5lF7$^$&!#$^$?!"%9%T!<%+$G:F@8$9$k>l9g!"%9%T!<%+$HD0<h<THK$O0lDj$N5wN%$,$"k?$a!">2LL$JIKhkH?<M2;dJIN;D6A2;$,2C$ok?$a!"D0<h<T$N6a$/$K2;A|$rDj0L$7$?$$;~$K8z2L$,F@il$J$$>l9g$,$"kH$$$&h&$J7gE@$,$"$k[16]!#

3Nh&K=l>lN:F@87OK*$$$F$b=>Mh$N%9%F%l%*GOD0<h<T$r94B+$7F7$^$&NG!"<}O?4D6-$HF1$84D6-$rF@$kKOHs>o$K:$FqG"k3H,J,$+$k!#$=$3$G!"<}O?$7$?2;@<$r3D %5%&%s%I:F@85;=QKh$j2C9)$9k3HG!"D0<h<T$NOLCV$NLdBj$r2r7h$9$k!#$3lHOJLK=hM}B.EYK*$$$F$b!"2hA|=hM}$HF1MM$K2;@<=hM}$b@lMQ$N%O!<%I%&%'%"!JDSP JI!K$rMxMQ$9k[INBgNL$N=hM}$rI,MWH9$k!#0J>e$Nh&$JGX7J$+$i!";~4VHHbKJQ2=9k%G%#%8%?%kO?2;$5l?2;@<%G!<%?$r!"@lMQ$N%O!<%I%&%'%"$rMQ$$$:!"3D %5%&%s%I8z2L$r%Q!<%=%J%k%3%s%T%e!<%?>e$G<B8=$9$k 3D %5%&%s%I@8@.%7%9%F%`$N9=C[$r9T$&!#

K\8&5fGO!"3D %5%&%s%I@8@.%7%9%F%`$K$*$1$k>v$_9~$_7W;;$K$D$$$N8!F$!"$=$l$r%Q!<%=%J%k%3%s%T%e!<%?>e$G<B8=$9$k!#:#2s<B8=$9$k%7%9%F%`$O2;6A%7%_%e%l!<%7%g%s$H$$$&bN$G!"<B:]$K%[!<%kJI$G7WB,$5l?%G!<%?!JI$%s%Q%k%91~Ez!K$r>v$_9~$_7W;;9k3H$G!"$=$N%[!<%k$r:F8=9kbNG"$k!#%$%s%Q%k%91~Ez$O8&5f<<$G9XF~7?RSS(Roland Sound Space Processor) $rMxMQ$7:n@.9k!#2;@<%G!<%?$NF~=PNOIt$N:n@.$b9T$$!">v$_9~$_1i;;$r9T$&A0$N=hM}$GI,MWH9$k FFT !&FFT(9bB.%U!<%j%(JQ49!&bB.5U%U!<%j%(JQ49) =hM}ItHNO"7k$b9T$&!#$^$?>v$_9~$_7W;;GO!"FFT $rMQ$$$k3H$G%W%m%0%i%`$N4JN,2=$r?^$C$?!#$3$l$K$h$jFFT It$H$NO"7k$b4JN,2=$G$-$k$3$H$K$J$k!#$^$?3F%W%m%0%i%`$NO"7k

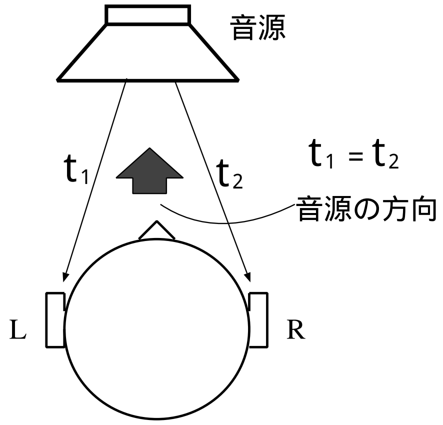
KO!"%&%$%s%I%&$r:n@.$7!"$=$N%&%$%s%I%&$K2;@<%U%!%$%kFI$_9~$_$d>v$_9~$_$N<B9TJI $N5!G=$r;}$?$;k3HK9k!#J*%Q!<%=%J%k%3%s%T%e!<%?>e$N3+H/8@8l$H7F Microsoft <R$N Visual C++5.0 $r;HMQ$7$?!#

K\O@J8GO$^$:#2>O$G4pK\E*$J2;@<NEAo$jJ}$+$i 3D %5%&%s%I$NCN3P$H!"3D %5%&%s%I @8@.5;=Q$H7F!"%P%$%N!<%i%kO?2;!"2;6A%7%_%e%l!<%7%g%s!"B?%A%c%s%M%k%9%F%l%*:F@8 KD$$$F35MW$r@bL@$7$F$$$/!##3>OGO 3D %5%&%s%I@8@.%7%9%F%`$K$D$$$F<B8=J}K!$H%7 %9%F%`A4BN$NN.$lJI$r@bL@$7!"FC$K%G!<%?7W;;It$K$*$1$k>v$_9~$_7W;;$O!"%G%#%8%?%k ?.9f=hM}$N4pAC$+$i FFT Kh$k4JN,2=$^$G>\$7$/@bL@$9$k!##4>O$G$O%7%9%F%`$NI>2AH7 $F=>Mh$N%9%F%l%*HNHf3S$H RSS HNHf3S$r9T$&!#

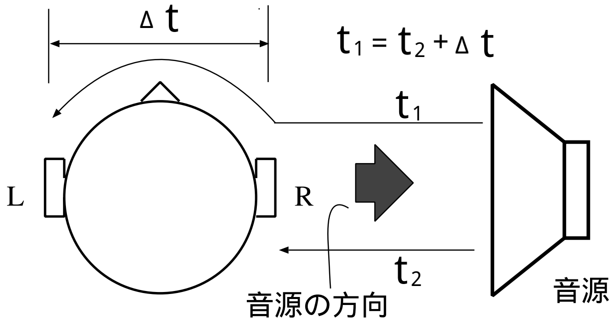
2 3D %5%&%s%I$NCN3P$H35MW

2.1 3D %5%&%s%I$NCN3P

3D %5%&%s%I$NCN3P$NA0$K!"?M4V$O2;$NJ}8~$rINh&$KG'<1$7$F$$$k$+$K$D$$$F@bL@9k!#$3$1$O?M4V$N<*$,:81&$K#2D"k3HKM}M3$,$"$k!#?^1$Nh&$KA0J}@5LL$K$"$k2;8;$+$i2;$,E~Mh$7$?$H2>Dj9k$H!"$3$N2;$O:81&$N<*$KF1;~KFO/$?$a!"2;8;$,A0J}@5LL$K$"$k3H$,J,$+$k!#F1MM$K2;8;$,1&B&??2#$K$"$k>l9g!"?^2Nh$&$K:8<*KFO/;~4V$,D9$$$3HH!"4i$r2s@^$7$F2;$,FO$/$?$a2;<A$bJQok3H$G1&B&??2#$K2;8;$,$"k3H,J,$+$k[13]!#

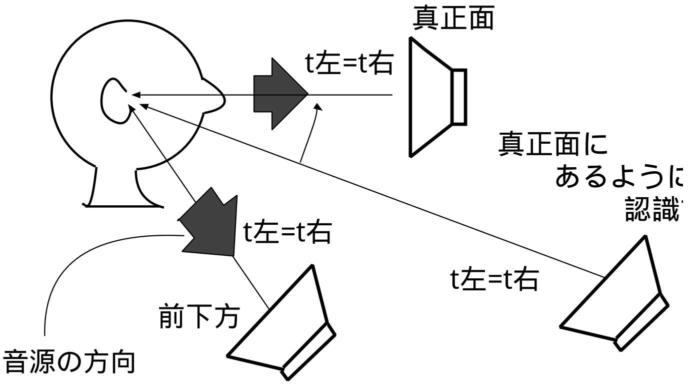


?^1: A0J}@5LL$N2;8;$NCN3P



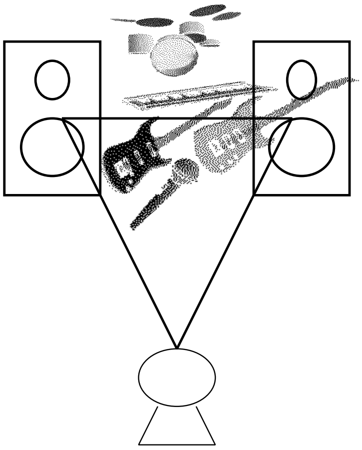
?^2: 1&B&??2#$N2;8;$NCN3P

<!$K2;$N9bDcOINh$&$KH=CG9k$+$K$D$$$F!"?^3Nh$&$K2;8;$,??@5LL2<$K$"$k$H2>Dj$9kH!":81&$N<*$KE~Mh9k2;$K;~4V:9$O$J$$$?$a!"2;8;$,$9$06a$/$K$J$$8B$j!"9bDc$K$D$$$F$OH=CG$,D+$:!"??@5LL$K$"$kh&$KG'<1$9$k!#$7$+$7!"2;8;$,6a$/K"$k>l9g$O4i$r2s@^$7$FEAHB$7!"7+$b<*$NFL1zKhCF2;<A$,JQ2=$9k?$a!"2<J}$K$"$k3H$,$o$+$k[13]!#

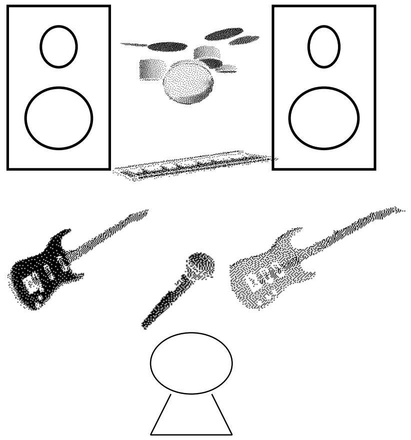


?^3: ??@5LL2<J}$N2;8;$NCN3P

<!$K!"8=:_:G$b0lHLE*$J%9%F%l%*%5%&%s%I$NCN3P$r@bL@$9$k!#%9%F%l%*$O#2%A%c%s%M%k$G2;>l$r:n$j=P$7$F$$$k!#?^4Nh$&$K#2DN%9%T!<%+$rD1lJU$H9k#2EyJU;03Q7A$ND:E@>e$K2;A|$,Dj0L$9$k;EAH$_G"$k!#3D%5%&%s%I$O$3$10J30$N0LCV!"Nc$($P?^5$Nh&$K%9%T!<%+$N30B&$dD0<h<T$N8emd??2#$+$i2;$,J9$3$($k3H$r8@$&[5]!#

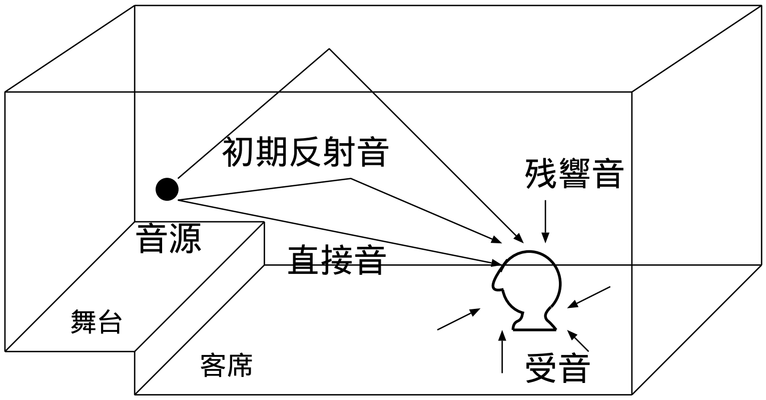


?^4: %9%F%l%*$N2;A|Dj0L



?^5: 3D %5%&%s%I$N2;A |Dj0L

$^$?!"?^6$O<u2;<T$X$N2;$NEAojJ}$r<($9bN$G!"$^$::G=i$K !D>@\2;!W$,EAHB$9$k!# 3N2;$O2;8;$H4Q5R$r:GC;5wN%$G7k$S!":G$bB.$/EAHB9k!#<!$KE~Mh9k2;$O!"!∀i4 |H?<M 2;!WG"$k!#3N2;$OIqBf$NH?<M$dJI!"E70f$JIKH?<M9k=i4 |CJ3,$NH?<M2;G"$k!#=i 4 |H?<M2;$O!"D>@\2;$,FO$$$F$+$iLs50msec 0JFb$KE~Mh$9k?$a!"?M4V$OD>@\2;$HF1$82; $H46$8$k!#:G$bCYlFE~Mh9k2;$O !}VD6B2;!W$G$"$j!"3N2;$O<<Fb$N$$$m$$$m$JFbAu$d JI$K4vEY$HJ/VD$+$j8:?j7F$$$/2;$G!"D>@\2;$NE~Mh8e!"Ls50msec 0J9_$+$iE~Mh$7!" =y!9$K8:?j7F$$$/[13]!#



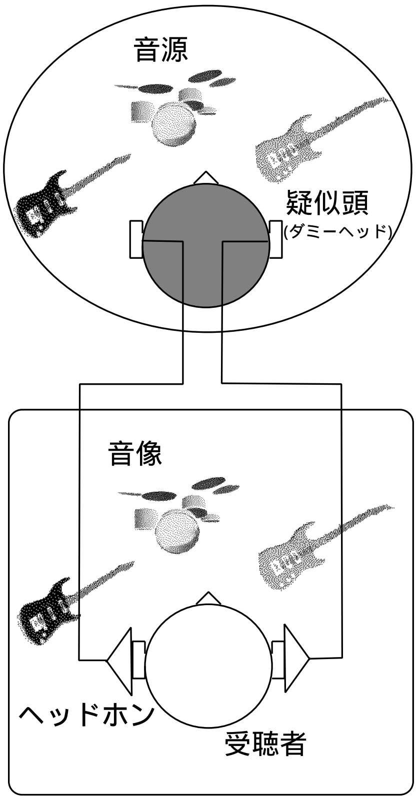
?^6: <u2;<TXN2;NEAo$jJ}

2.2 3D %5%&%s%I@8@.5;=Q

2.2.1 %P%$%N!<%i%kO?2;

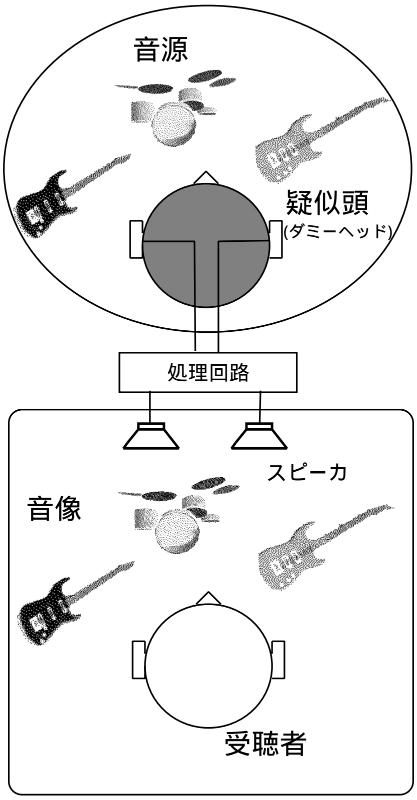
2;8;$NJ}8~CN3P$J$I!"D03P$K$*$1$k6u4V>pJs$NGD0.$O!"$*bKN><*<uD0KhCF9Tol$k!#%9%T!<%+$rMQ$$$?<uD0GO!":F@8B&$N2;>l$N1F6A$r<u$1d9$$!#=>CF!"N><*CN3P$r@53N$KLO5<7?$$>19g$O!"%X%C%I%[%s<uD07O$+$i<h$jAH$`I,MW$,$"$k!#?M4V$,<B:]$N4D6-NCfG2;$rD0$$$F$$$k>u67$r9M$(kH!"N><*$N8]K16aK5$GHi$($ilk2;$N?.9f$r=82;7F:FS=$N?.9f$G%X%C%I%[%s:F@8$r9T$($P!"Ci<B$JNW>l46$,:F@8$G$-$kO:G"$k!#$3l,%P%$%N!<%i%k !NJ><*!K:F@8$N4pK\E*$J9M$(J}G"$k!#

%P%$%N!<%i%kJ}<0$H7F$O!"5<;wF,!J%@%_!<%X%C%I!K$N8]K10LCV$K%^%$%/%m%[%s$r<hjIU1$F!"$3lKhC$F#2%A%c%s%M%kO?2;$5l??.9f$r%X%C%I%[%s$G:F@8$9$kJ}K!$,:G=i;n$5$l!"2;$NJ}8~CN3P!"9JoA2;A|Dj0L$K8z2L$,$"$k3H$,3N$+ail?!#7+$7!"5<;wF,$rMQ$$$?D>@\O?2;$r9T$&$H!"?.9f$NCf$K!"?M4V$NF,It$H<*2p$KhC$F2s@^$7$?EAC#FC@-$,=ia+$i4^$^lF7^$&$N$G!"DL>o$N%9%F%l%*O?2;HO8_49@-rHkN$,Fq$7$$$H$$$&LdBj$,$"$k!#?^7$O%P%$%N!<%i%k7O$N86M}$r<($9[2]!#



?^7: %P%$%N!<%i%k7O$N86M}

%9%T!<%+:F@8Kh$j!"%P%$%N!<%i%k7O$HF1$8h&$K<uD0<T$NN><*K=l>lN?.9f$,EA$okh$&$J;EAH$_$r:nk3HO%H%i%s%9%*!<%i%k7O$H8F$P$l!"?^8$K86M}$r<($9!#3N>l9g!"%9%T!<%+$H<uD0<T$H$N4V$KEAC#FC@-$rJd=~$9kI,MW,$"$k[2]!#



?^8: %H%i%s%9%*!<%i%k%7%9%F%`

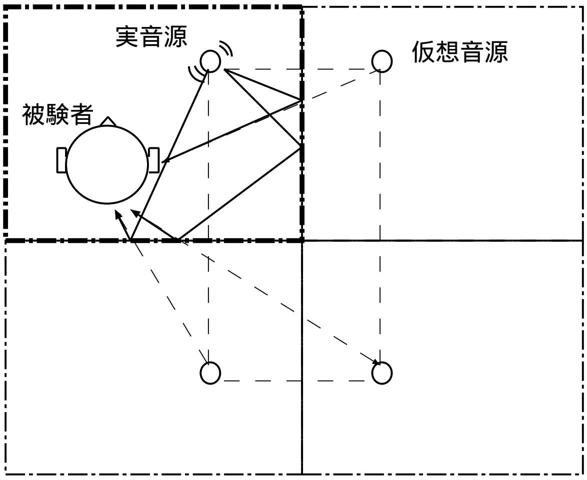
2.2.2 2;6A%7%_%e%l!<%7%g%s

2;6A%7%_%e%l!<%7%g%sGO!"H?<MGH$N1F6A$r4^s@2;6A?.9f$N9g@.$r9T$&!#%3%s%5!<%H%[!<%k$JIN2;>l$r@_7WCJ3,$GM=B,9k$?$a$K!"7zC[2;6A@_7W$NJ,LnG5$^$6$^$J<jK!$,Ds0F$5$l<BMQ$5lF$$$k[2]!#

(1) 4v2?2;6A%b%G%k

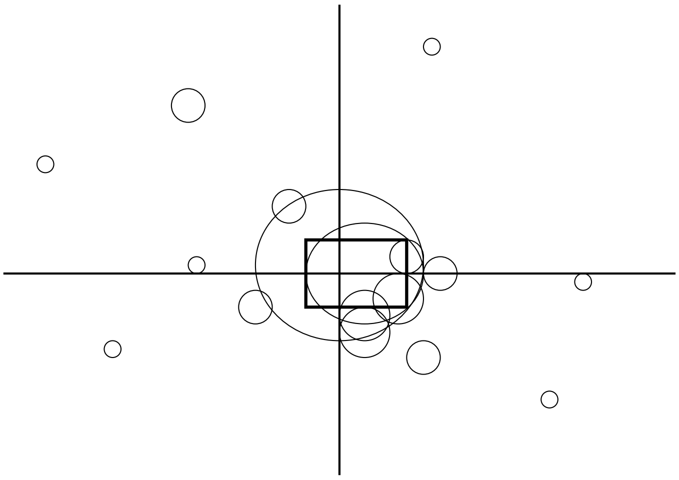
%3%s%T%e!<%?%7%_%e%l!<%7%g%sKO2;@~K!$H5uA|K!$,h/MQ$$$ilk!#2;@~K!$O!"2;GH$r2;8;$+$i$ND>@~E*$J?J9T$ND I@W$G%b%G%k2=9kbN$G!"%3%s%T%e!<%?%0%i%U%#%C%/%9JI$KMQ$$$ilF$$$k%l%$%H%l!<%7%s%0$HN`;w$N<jK!$G$"$k!#0lJ}!"6u4VA4BN$NH?<M2;$N9=B$$rM}2r9k$?$aKO!"2>A[2;8;J,I[$G5-=R$9$k5uA|K!$,MQ$$$ilk!#3l$O<<Fb$NH?<MFC@-JI$r%b%G%k2=$9k3HKhC$F!"0lCV$H2;$N6/$5$r%Q%i%a!<%?$K7?2>A[2;8;$NJ,I[$r4v2?3XE*$K5a$a$F$$$/J}K!G"$k!#

?^9$ON)J}BN$NIt20NFsD$NJILL$KBP9k#1<!H?<M$H#2<!H?<M$NEAHB$NMM;R$r<(7F$$$k$,!"$3li$NH?<MGH$O!"JI$r<h$j=|$$$?>uBVGN2>A[2;8;$+$i$ND>@\GH$H7FCV-49(ilk3Hr<(7F$$$k!#

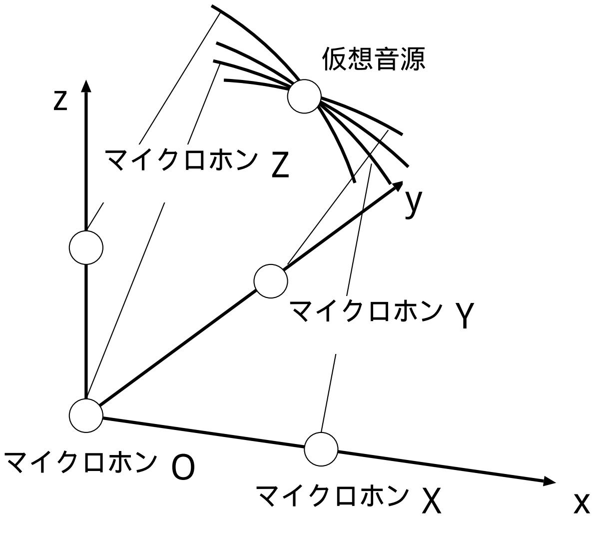


?^9: 2;$NH?<M$H2>A[2;8;

?^10$O2>A[2;8;$NJ,I[?^G"$j!"1_$NCf?4$,2>A[2;8;$N0LCV!"Bg$-$5$O6/$5$rI=$9!#3N<B:_9k2>A[2;8;J,I[$r5a$ak?aK$O!"6a@\#4E@K!$H8FPl$k7WB,K!$,MQ$$$ilk!#3NJ}K!$O?^11$K<(9h$&$K6u4V>e$N?bD><4$N86E@$H!"$=l+$iEy5wN%$K$"$k#3E@$N9g7W#4E@$N%^%$%/%m%[%s$rMQ$$$k!#L5;X8~@-$N2;8;$r@_CV7?>uBV$GEAC#4X?t$rB,Dj$7!"AG$NC;;~4V$"$?jNAj8_Aj4X4X?t$r7W;;$9k3HKhC$F!"2>A[2;8;$N0LCVHBg-5,;XDjG-$k!#



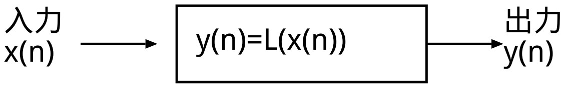
?^10: 2>A[2;8;$NJ,I[



?^11: B,DjJ}K!

(2) %$%s%Q%k%91~Ez$Khk2;6A%7%_%e%l!<%7%g%s

3l$+$i@bL@9k2;6A%7%_%e%l!<%7%g%s$O!"7z@_A0$K9T$&%[!<%k$N2;6A%A%'%C%/KO1/10 $NLO7?$r;H$&$3H,B?$$!#%_%K%A%e%"$N%[!<%k$r:n$j!"$=NCfG2;6A$K4X$9$k<B83%G!<%? $r<}=8$9kNG"$k!#8=:_$G$O%_%K%A%e%"LO7?$NCf$K%$%s%Q%k%9$rH/@8$5$;$F!"$=$N%$%s %Q%k%91~Ez$NGH7ArB,Dj7!"$=$N%G!<%?$r4p$KL56A<<$G1iAU$5l?2;3Z$N%5%&%s%I%G!<%? $K2;6A%7%_%e%l!<%7%g%s$r;\$9<jK!$,9T$olF$$$k!#0J>eN3H+$i%$%s%Q%k%91~EzKh $j!"2;6A%7%_%e%l!<%7%g%s$,2DG=G"k3HrM}2r9kKO!"?^12Nh$&$J@~7AF~=PNOAu CVK*1k>v$_9~$_7W;;$rM}2r$7J1lPJi$J$$!#<0(1) $O?^12$K$*$1$k%$%s%Q%k%91~ Ez$r5a$a$k<0$G$"$k!#$^$?<0(2) $O@~7A>v$_9~$_$H8FPl$k<0$G$"$j!"2;6A%7%_%e%l!<%7%g %s$r9T$&>eGN=EMW$J=hM}$HJk!#

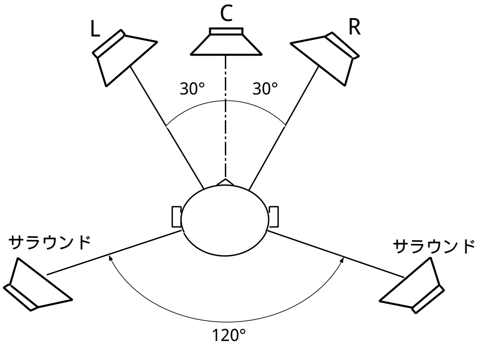


?^12: @~7AF~=PNOAuCV

$$
\begin{aligned}
h(n) &= L(\delta(n)) && (1)\\
y(n) &= \sum_{n=-\infty}^{\infty} h(n-m)x(m) && (2)
\end{aligned}
$$

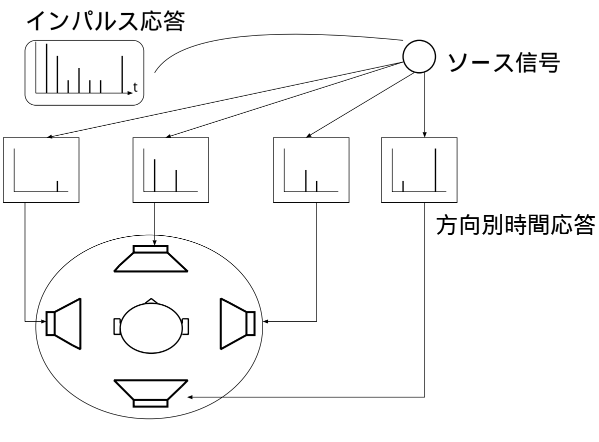
2.2.3 B?%A%c%s%M%k%9%F%l%*:F@8

NHK $N%O%$%S%8%g%sMQ2;6A%7%9%F%`H7$F!"A0J}#3%A%c%s%M%k!"B&!&8eJ}#1%A%c%s%M%k$N3-1 J}<0$,Ds0F5l$F$$$k!#3NFHN)#4%A%c%s%M%kJ}<0$r3NN)$9kK$"$?CF!"INh&$JG[CV$,9%$^$7$$$+8!F$$,J5$l!"?^13$K<(9h$&$JG[CV$,2;A|8z2L$KM-8zG"k3H,J,$+$C$F$$$k[2]!#



?^13: %O%$%S%8%g%sMQ3-1 J}<0

$^$?A0$N>O$G$b@bL@$7$?%P%$%N!<%i%k%7%_%e%l!<%7%g%s7O$G@bL@$7$?2>A[2;8;J,I[(?^10;2>H) r=N^$^:F8=$9$k>l9g!"B?%A%c%s%M%k%9%T!<%+:F@8$,M-8z$KJk!#2>A[2;8;J,I[$rJ}8~JL$K$^$Hak3HKh$j!"J}8~JL$N%$%s%Q%k%91~Ez$r9g@.9k3H$,$G$-$k!#3NJ}8~JL$N1~Ez$r2;8;?.9f$K=E>v$7$F!"8DJL$N%9%T!<%+$rMQ$$$F:F@8$9$k3HKh$j!"6u4V2;6A$r:F@8$9$k!#?^14K=$N86M}$r<($9[2]!#

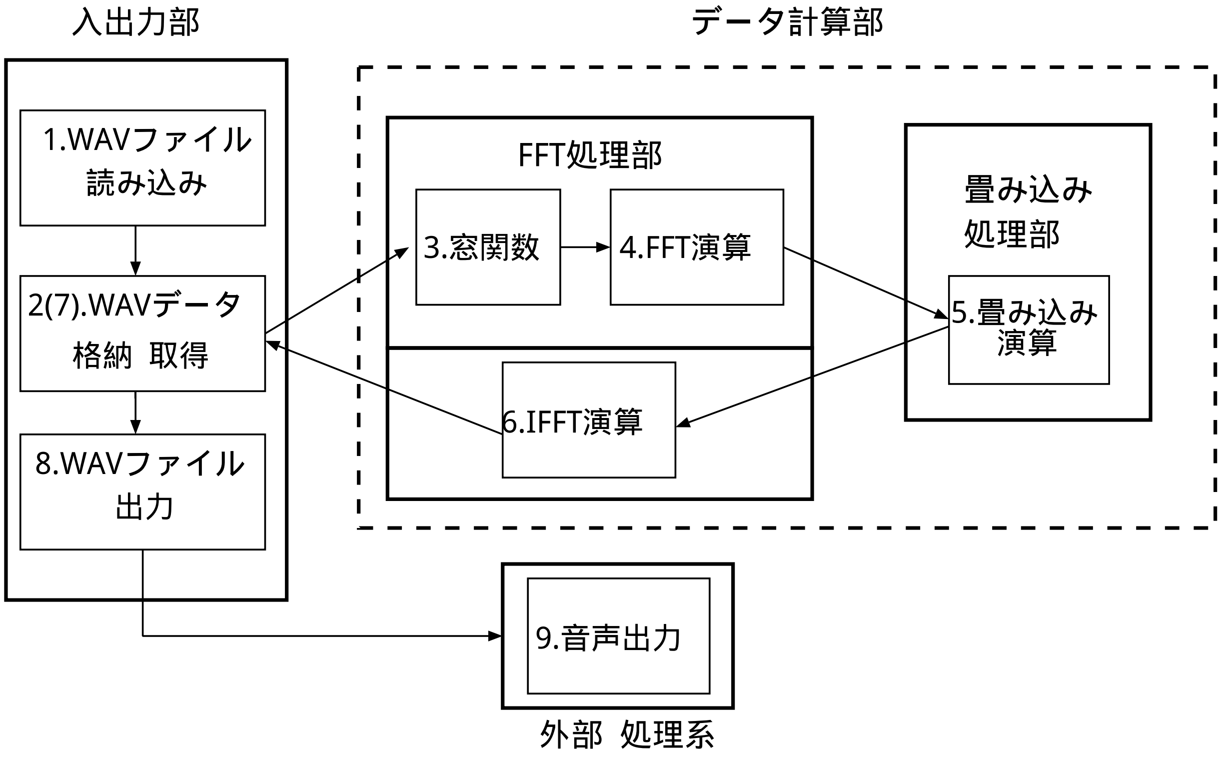


?^14: J}8~JL%$%s%Q%k%91~Ez$rMQ$$$?B?%A%c%s%M%k:F@8

3 3D %5%&%s%I@8@.%7%9%F%‘

3.1 %7%9%F%‘A4BN$N9=@.

K\%7%9%F%‘$O!"F~=PNOIt$H%G!<%?7W;;ItNBg-$/#2$D$N9=@.It$KJ,$+$l$F$$$k!#%G!<%?7W;;It$O!"FFT =hM}It$H>v$_9~$_=hM}It$KJ,$+lF$$$k!#?^15$O%7%9%F%‘$NN.lr<($7!"3F9=@.It$N>\:Y$r<!$N@a$G@bL@$9$k!#



?^15: %7%9%F%‘$NN.$l

3.1.1 F~=PNOIt

F~NOIt$G<h$j0 7$&%G!<%?$O!"%Q!<%=%J%k%3%s%T%e!<%?>eGh$/;H$olF$$$k WAV 7A<0$N2;@<%G!<%?$rMQ$$$k!#WAV 7A<0$O Windows95 JI$GI8=`$N2;@<%U%)!<%^%C%HG"$k!#?^16$O WAV %U%!%$%k$N%G!<%?9=B$$rI=$7!"0J2<$K$=$N%G!<%?9=B$$NFbMF$r@bL@$9$k[15]!#

WAV %U%!%$%k$NA4BNH7FO RIFF %A%c%s%/$H$$$&RHDN%V%m%C%/KJCF$$$k!#$^$?!"$=$N RIFF %A%c%s%/<+BN$NCf?H$b!"$$$/D+$N2<0L%A%c%s%/$G9=@.5l$F$$$k!#

- **RIFF** %A%c%s%/!%U%!%$%kA4BN$rE}3g9kbNG"$j!"formType $K"WAVE" $HI=5-$5lk3H$G!"$3$N%U%!%$%kA4BN$,!WAVE %U%!%$%k$N%G!<%?!W$G$"$k3H$,$o$+$k!#
- **fmt** %A%c%s%/!$3$3KO!"<!Nh$&$J%5%&%s%I%G!<%?>pJs$,5-$5lk!#
  - **waveFormatType** !%5%&%s%I%G!<%?$N7A<0$rI=9bNG!¥1!WNH$-$K%j%K%"PCM HJ$k!#B>$K$b$$$/D+$N7A<0$,$"$k$,!"%Q%=%3%s$G0 7$&%5%&%s%I%G!<%?$O%j%K%"PCM $,0lHIE*!#
  - **channel** !%A%c%s%M%k$N?t$G!"!¥1!WNH$-%b%N%i%k!"!¥2!W$NH-%9%F%l%*HJ$k!#
  - **samplesPerSec** !%5%s%W%j%s%0<~GH?t$rI=$9!#11025Hz,22050Hz,44100Hz JINCM,0lHIE*!#
  - **bytesPerSec** !#1IC4VKI,MWJ%G!<%?$N%P%$%H?t$rI=$9!#%5%s%W%j%s%0<~GH?t!"%A%c%s%M%k?t!"NL;R2=%S%C%H?tJI$NMWAG$KhC$FD|j$^$k!#
  - **blockSize** !%G!<%?:G>.C10L$N%P%$%H?t$rI=$9!#8bit mono Ji!¥1!W"8bit stereo Ji!¥2!W"16bit mono Ji!¥2!W" 16bit stereo Ji!¥4!WHJ$k!#
  - **bitsPerSample** !NL;R2=%S%C%H?t$rI=$7!"0lHIE*KO!¥8!Wb7$/$O!¥1#6!WNCM,F~$k!#
- **data** %A%c%s%/!**chunkSize** NCMG%5%&%s%I%G!<%?N_$NAm9g%P%$%H?t$rI=$9!#%G!<%?NJBS$O?^17$Nh&KJCF$$$k!#$^$?8D!9$N%G!<%?$OI=1Nh$&$KJC$F$$$k!#

RIFFのチャンク

タイトル	バイト数	内容
chunkID	4	"RIFF"
chunkSize	4	チャンクのサイズ(sz+36)
form Type	4	"WAVE"

RIFFのチャンクのデータ

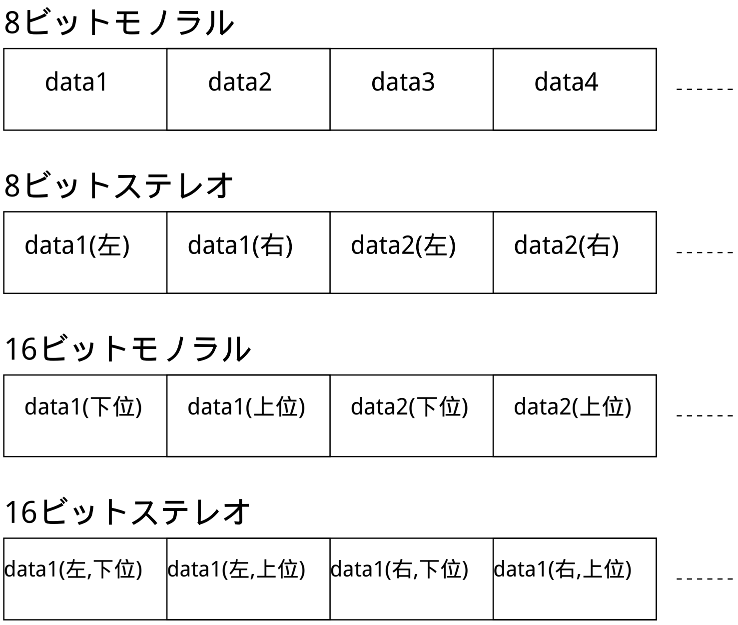
fmtチャンク

タイトル	バイト数	内容
chunkID	4	"fmt"
chunkSize	4	チャンクのサイズ(16)
waveFormatType	2	WAVデータ情報
channel	2	
samplesPerSec	4	
bytesPerSec	4	
blockSize	2	
bitsPerSample	2	

dataチャンク

タイトル	バイト数	内容
chunkID	4	"data"
chunkSize	4	sz(不定)
data	sz(不定)	WAVデータ

?^16: WAV %U%!%$%k$N%G!<%?9=B$



8ビットモノラル

data1	data2	data3	data4	------

8ビットステレオ

data1(左)	data1(右)	data2(左)	data2(右)	------

16ビットモノラル

data1(下位)	data1(上位)	data2(下位)	data2(上位)	------

16ビットステレオ

data1(左,下位)	data1(左,上位)	data1(右,下位)	data1(右,上位)	------

?^17: WAV $N%G!<%?JB$S

I=1: WAV $N%G!<%?$NI=8=

	:G>.CM	Cf1{$NCM	:GBgCM
8 %S%C%H%G!<%?	0	128	255
16 %S%C%H%G!<%?	-32768	0	32767

F~NOItGOWAV %U%!%$%k$NFI$_9~$_!"$*$h$SA4%U%!%$%k%G!<%?$N3JG<!&hF@$r9T$&!#$3$1$O!"%5%&%s%I%G!<%?HOD>@\4X78$J$$>pJsrFI_HtP7!"4X78N"kbN@1r@53N$K<hF@$9kI,MW,$"$k!#$^$?<B:]$K%5%&%s%I%G!<%?$N;O$^$k0LCV$b@53N$KGD0.9kI,MW$,$"$k!#

=PNOItGO%G!<%?7W;;It$G=hM}$5$1$?%5%&%s%I%G!<%?$rF~NOIt$HF1MM$K3JG<!&hF@$r9T$$!"WAV %U%!%$%k$r=PNO9k!#=PNO$5$1$?WAV %U%!%$%k$O30OIt=hM}7O!JWindows95 GO%5%&%s%I%W%l%$%d!<$J$I!K$G:F@8G-$k!#

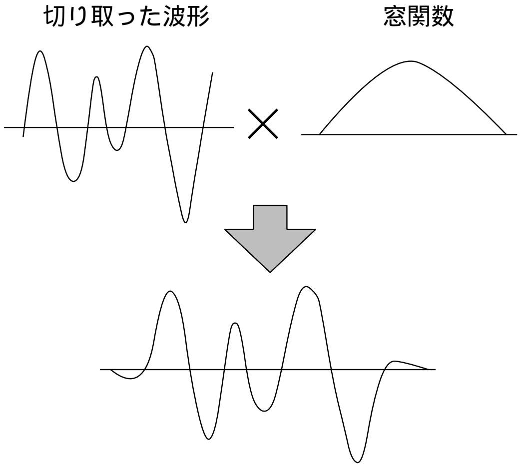
3.1.2 %G!<%?7W;;It

%G!<%?7W;;ItGOFFT =hM}It$H>v$_9~$_=hM}It$N#2DKo+lF$$$k!#%G!<%?7W;;It$NN.$l$r0J2<$K@bL@7F$$$/!#$^$?!"3F=hM}It$N>\:Y$O<!$N>O$G@bL@9k!#

(1)FFT =hM}It

FFT $O;~4V<4>e$NGH7A$r!"<~GH?t<4>e$N<~GH?t@.J,$KJQ49$9kbNG$"$k!#FFT =hM}$NA0$KAk4X?t$N=hM}$r9T$&$,!"3l$O?^18$Nh&$J=hM}$G$"$k!#<B:]$NFFT =hM}$O;~4V<4>e$NGH7A$rM-8B8D$NGH7A%G!<%?$H7F@Z<h$j!"$=lr=hM}8eDJ$.9g$o$;$k!#3N$?$a?^18$N@Z$j<hG?GH7A$r=hM}$9$k>l9g!"$DJ.L\$,ITO"B3$J>l9g$,$"$k!#3lrKI0$?$a$KAk4X?t$r3]$19g$o$;$k=hM}$r9T$&[1]!#

$^$?>v$_9~$_=hM}Ithj@8@.7?%G!<%?$OIFFT =hM}$Khj!"<~GH?t<4>e$N<~GH?t@.J,$r;~4V<4>e$NGH7A$KJQ49$9$k!#



?^18: Ak4X?t

(2) >v$_9~$_=hM}It

>v$_9~$_=hM}ItGO!"M=$a7WB,$7$?%$%s%Q%k%91~Ez!6A$-$NMWAG!K$r>v$_9~$_1i;;$9k3HG!"K\8&5f$N2]Bj$G$"$k3D %5%&%s%I$r@8@.$9$k!#

3.2 #F#F#T$H#I#F#F#T

FFT $N@bL@$r9kA0$K!"FFT $N4pK\$HJkDFT(N%;6%U!<%j%(JQ49) KD$$$F@bL@9k!#N%;6E*$J%G!<%?$r%U!<%j%(JQ49KhCF<~GH?t@.J,$KJQ49$9kbNG$"$k!#$^$?IDFT O=$N5UJQ49$G!"<~GH?t@.J,$r85$N%G!<%?KLa9JQ49G"$k!#$3$1$i$NJQ49<0$OFFT $O<0(1)!"IFFT $O<0(2) Nh$&KJk,!"$3$3$G<(7?<0$NN $,2 $NN_>h$G$"$kH-!"$=$N=hM}$,9bB.$K9T$($k$H$$$&@-<A$,$"$k!#$3$N9bB.JQ49%"%k%4%j%:%`$rMxMQ7?bN$,FFT G"$j!"$^$?$=$N5UJQ49$,IFFT G"$k!#

$$F(k) = \sum_{n=0}^{N-1} f(n) e^{-i2\pi\frac{nk}{N}} \qquad (3)$$

$$f(n) = \frac{1}{N} \sum_{k=-\frac{N}{2}}^{\frac{N}{2}-1} f(k) e^{i2\pi\frac{nk}{N}} \qquad (4)$$

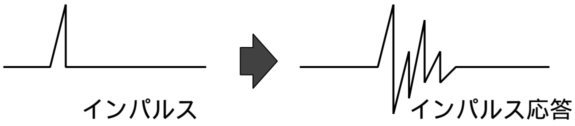
3.3 >v$_9~$_7W;;

3.3.1 %$%s%Q%k%91~Ez$H%G%k%?4X?t

%"%J%m%0?.9f$r07$&KO!"$$$/D+$N4pK\4X?t$,%7%9%F%`$r5-=R$9$k$N$KBgJQLrN)$C$F$$$k!#:G$b=EMW$J4X?t$O!"%G%k%?4X?t$\delta(t)$ $G$"$k!#$^$?!"%G%k%?4X?t$\delta(t)$ $rF~NO$7$?$H$-$N%7%9%F%`$N1~Ez$O%$%s%Q%k%91~Ez$H8FPl$k!#

- %$%s%Q%k%91~Ez

  %9%T!<%+$+$i$"$k0l=V$@$1?.9f$,0 GJ$$$h$&$J2;$r=P$7$?$H9k!#3NH-@)8f7?$$E@$G4QB,$5lk2;$r%$%s%Q%k%91~Ez$H$$$&!#?^19K=$NN.$l$r<($9!#



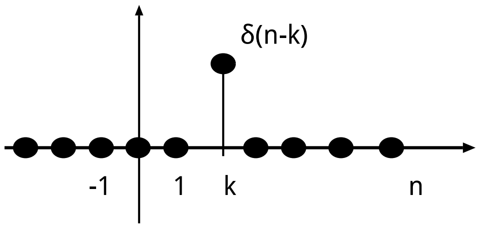
?^19: %$%s%Q%k%91~Ez

- %G%k%?4X?t

  %G%k%?4X?t$\delta(t)$ $ND>j5A$O0J2<$N<0$G$"$k!#

$$\delta(n)=1 \ (\mathrm{n=0})$$
$$\delta(n)=0 \ (\mathrm{otherwise})$$

?^20;2>H9k$H!"$\delta(n-k)$ $OL@$i$+$K$n=k$ $r=|$-Is$J%5%s%W%kE@$K$*$$$F$b0 NCMr<h$k!#



?^20: %G%k%?4X?t

3.3.2 #F#F#TKh$k>v$_9~$_7W;;$N4JN,2=

#2>O$G@bL@$7$?%$%s%Q%k%91~EzKh$k2;6A%7%_%e%l!<%7%g%s$r<B8=9k>l9g!"<0(5)Nh$&$JZ JQ49$H8F$PlkM}O@$rF3F~$9kH9k!#$=$&9kHN<0(7)$N>v$_9~$_7W;;$O<0(6)Nh$&$K%7%0%^$r<h$j=|$+$l$?<0$KJk!#$3$3$GN%;6?.9f$K$*$1$k%U!<%j%(JQ2=$O<0(7)Nh$&$KI=$;$k$?$a!"$3$1$O0l<o$NZ JQ49$H8+$J$9$3H,G-$k!#$7$?$,CFZ JQ49$HF1$8h&$K!"%U!<%j%(JQ49$K$*$$$F$b<0(8)$,@.N)9k!#0J>eN3H+$i FFT KhCF>v$_9~$_7W;;$,4JN,2=G-kNG"$k!#

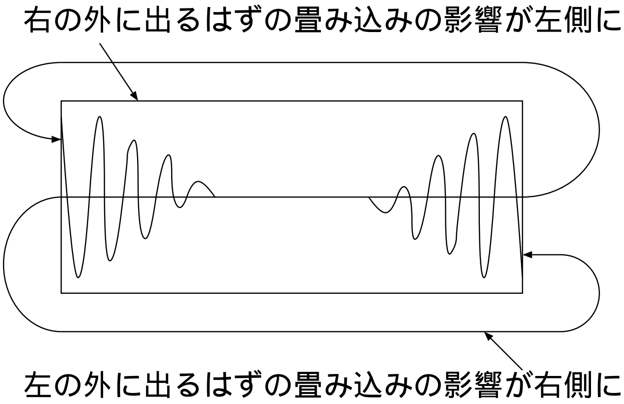
$$X(n)=\sum_{n=-\infty}^{\infty}x(n)z^{-n} \tag{5}$$

$$Y(z)=H(z)\cdot X(z) \tag{6}$$

$$X(e^{i\omega})=\sum_{n=-\infty}^{\infty}x(n)e^{-i\omega n} \tag{7}$$

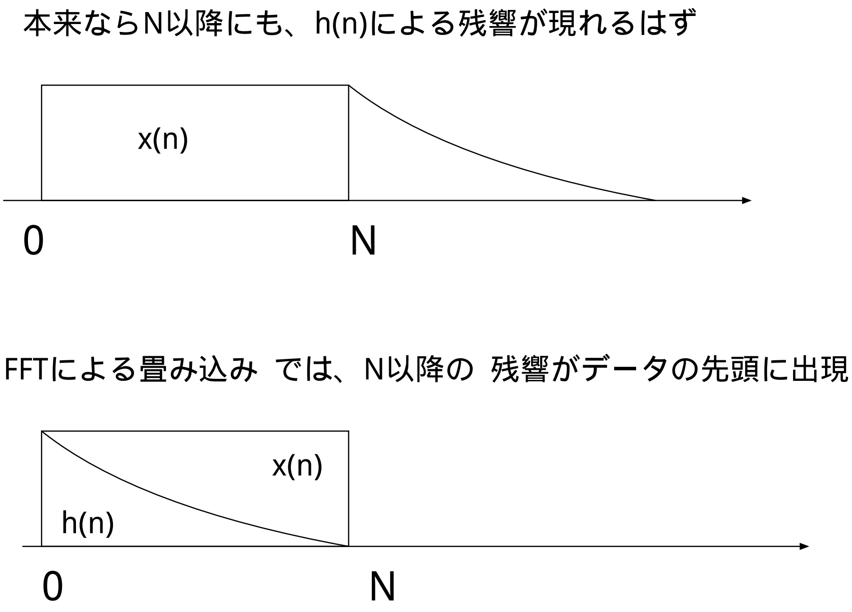
$$Y(e^{i\omega})=H(e^{i\omega})\cdot X(e^{i\omega}) \tag{8}$$

7+$7!"?^21$Nh&$K;~4V<4$N@5J}8~$K8=$lkO$:$N;D6A$,!"FFT KhCF;~4V@.J,$N%G!<%?$N@hF,$K=P8=$7F7$^$&!\d2s>v$_9~$_!W$,5/$-F7$^$&!#?^22$O?^21$rLO<0$7$?bNG"$k!#

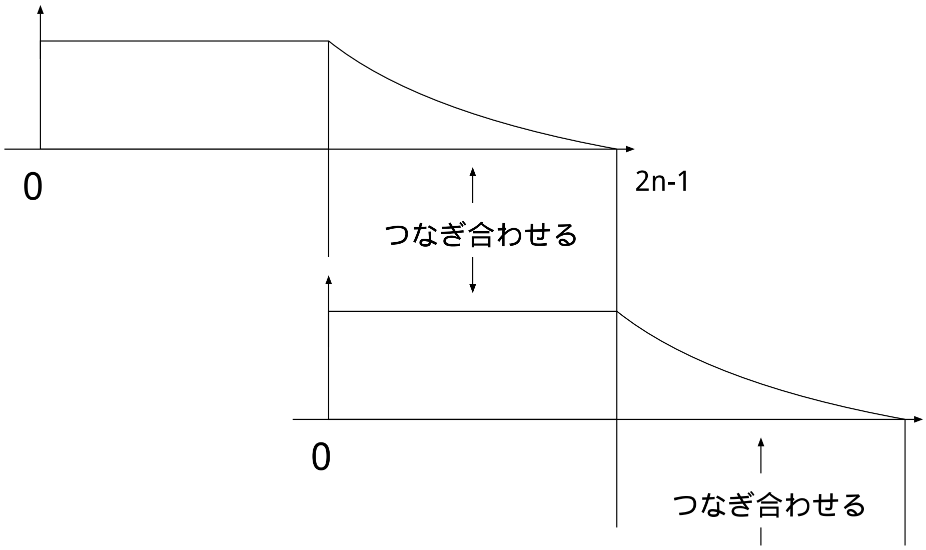


?^21: =d2s>v$_9~$_

=d2s>v$_9~$_$r2sHr$9$kJ}K!$H7F%*!<%P%i%C%W%"%IK!$,$"$k!#



?^22: =d2s>v$_9~$_$,5/$3$kMM;R



?^23: %*!<%P!<%i%C%W%"%IK!

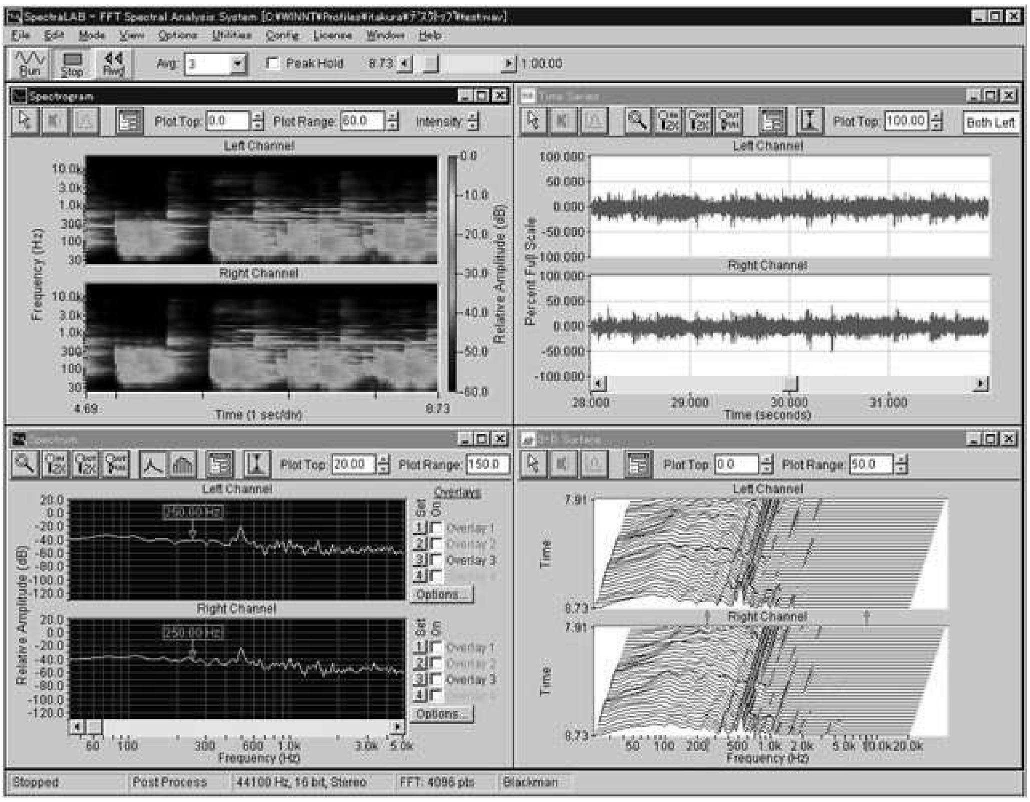
4 %7%9%F%`$NI>2A

%7%9%F%`$NI>2AJ}K!$H$7$FSOUND TECHNOLOGY <R$NSpectraSOFTest $H$$$&%9%Z%/%H%i%`%"%J%i%$%6!<%=%U%H$rMQ$$$F2;@<$rGH7A2=$9$k!#Hf3SBP>]$H7F=>Mh$N%9%F%l%*%G!<%?$HRSS(Roland Sound Space Processor) $G:n@.$7$?%G!<%?$rMQ$$$k!#

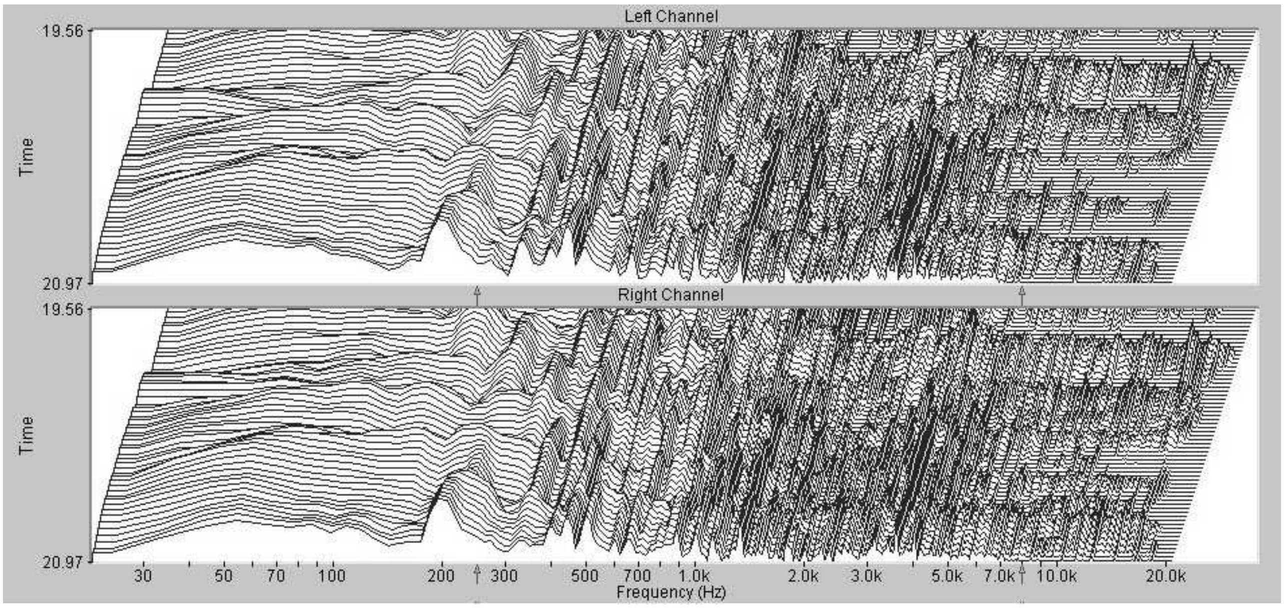
$=$l$>$l$N%G!<%?$HHf3S9kA0$KRSS $G:n@.$7$?%G!<%?$H%9%F%l%*%G!<%?$NHf3S$r9T$$!"3D %5%&%s%I$H%9%F%l%*$N0c$$$rL@3NK9$k!#

?^25!"26$O3-D %5!<%U%'%$%9$H$$$$=D<4$,;~4V!8T6E@$,8=:_$N;~4V!K!"2#<4$,<~GH?t!J0.0Hz!A20.0KHz!K$N%l%Y%k$rI=9bNG$"$k!#

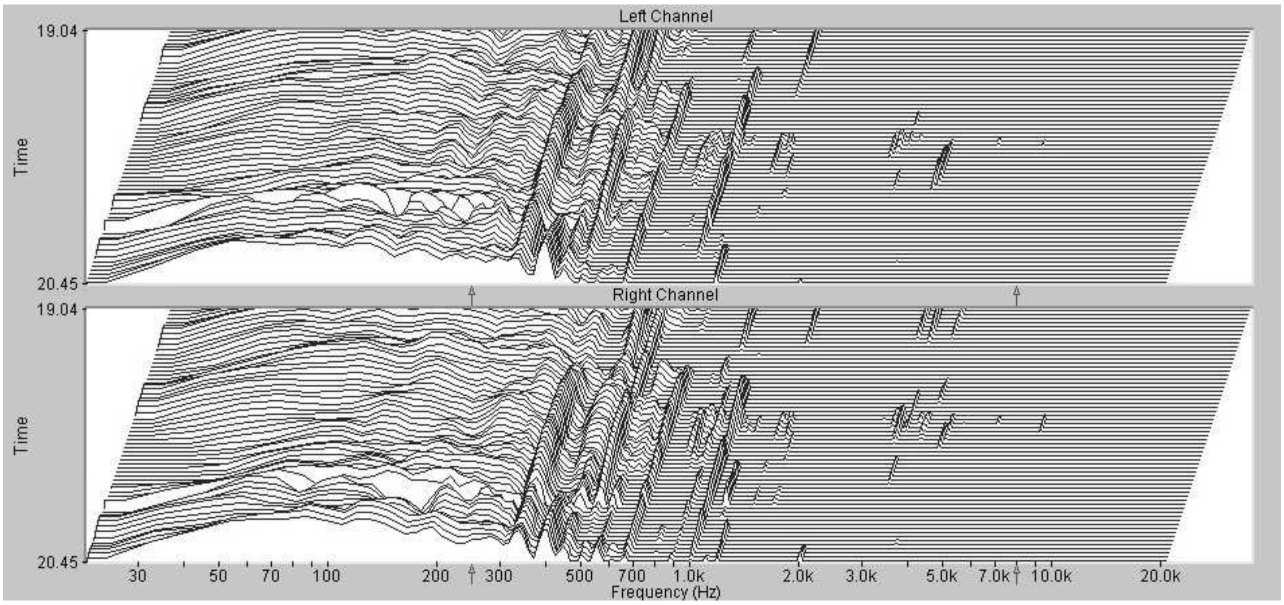
?^25!"26$r8+$k$HJ,$+kh$&$K!"%9%F%l%*$HRSS $G:n@.$7$?3D %5%&%s%I$H$N0c$$$OOC$-$j7F$$$k!#%9%F%l%*GO9-HO0O$K<~GH?tJ,I[$7$F$$$k3H$,$o$+$k!#5U$KRSS GO9b<~GH$NJ}KOJ,I[7F$$$J$$$3H,J,$+$k!#K\8&5f$O%$%s%Q%k%91~Ez$r>v$_9~$_7W;;$9k3HG3D %5%&%s%I$r@8@.$9$k!#$=$N%$%s%Q%k%91~Ez$ORSS $rMQ$$$F%5%s%W%j%s%0$7$?!#3N$?$a:#2s$N8&5f$G@8@.7?3D %5%&%s%I$,RSS $G:n@.$7$?%G!<%?$HF1$8$h$&$JGH7A%G!<%?$,<h$llP$$$$$3HKJk!#



?^24: %9%Z%/%H%i%`%"%J%i%$%6%=%U%H2hLL



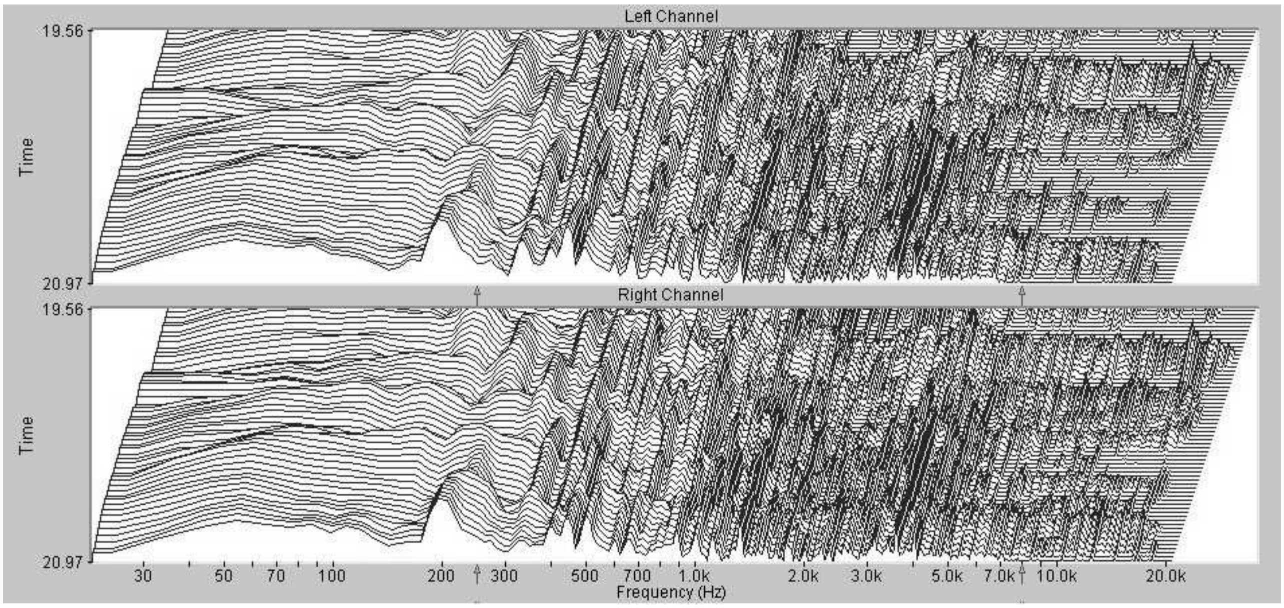
?^25: %9%F%l%*$NGH7A



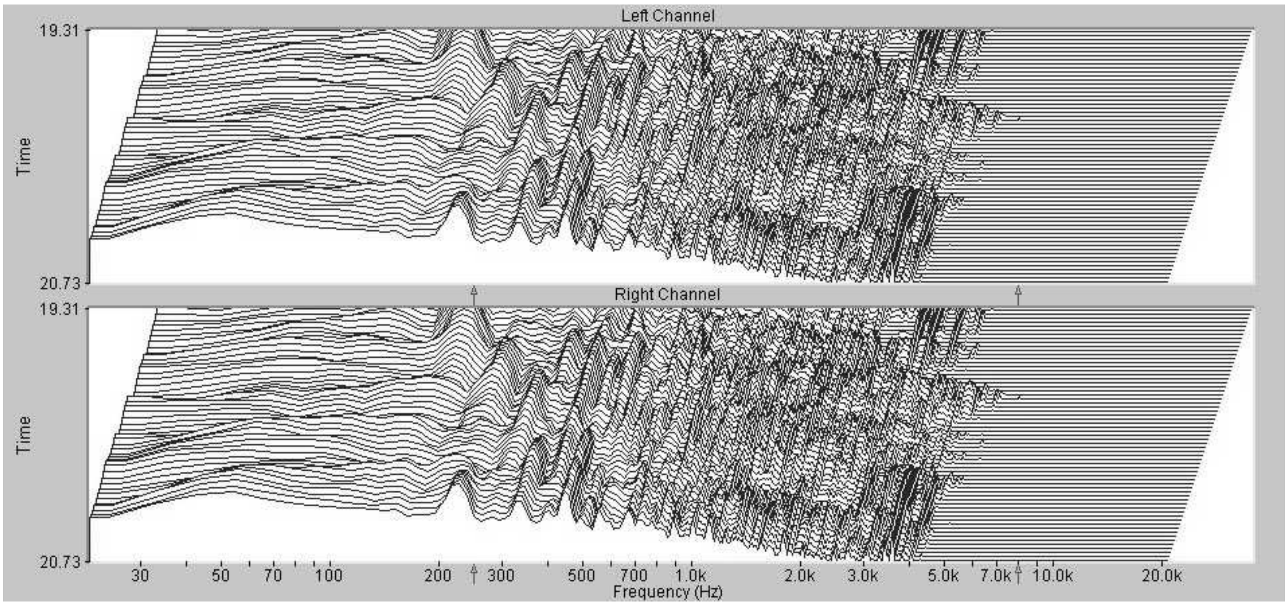
?^26: RSS $NGH7A

4.1 =>Mh$N%9%F%l%*$H@8@.G-$?N)BN2;6A$H$NHf3S

0J2<$K<($9?^$b4 >O$N:G=i$K@bL@$7$?3-D %5!<%U%'%$%9$GI=$7$?$bNG$"$k!#



?^27: %9%F%l%*$NGH7A



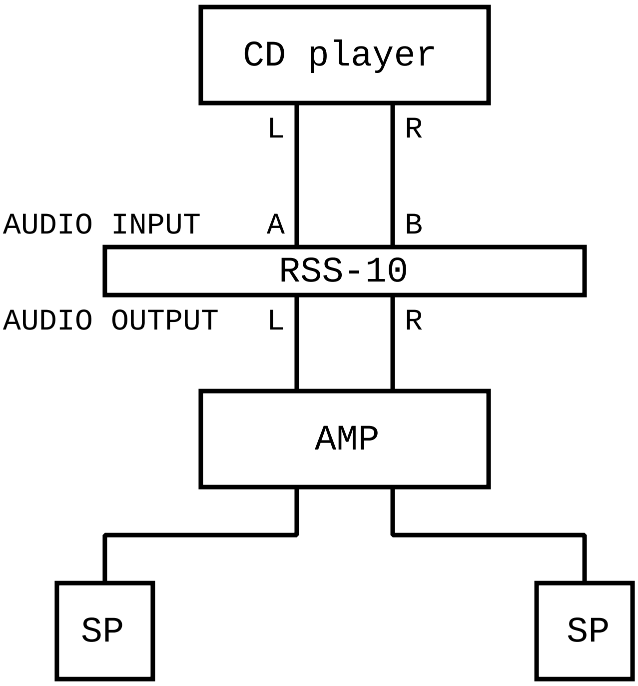
?^28: @8@.7?3D %5%&%s%I$NGH7A

?^27$H?^28$rHf3S9k$H@8@.$7$?3D%5%&%s%I$O!"A4BNE*$K3F<~GH?t%l%Y%k$,9b$/$JCF$$$k$,!"%9%F%l%*$[$I9-HO0O$K<~GH?tJ,I[5l$F$$$J$$3H,o+$k!#$3N3H+$i!"%9%F%l%*$H$O0c$C$?%5%&%s%I$,@8@.5l$?$3HKJk!#

@8@.7?3D%5%&%s%I$O9b2;$N3bC?2;0h$N69$$2;HJCF7^C?!#$^$?Dc2;0h$N2;05%l%Y%k$,9b$$$?$a!"2;$,3dlF7^$&$H$$$&8=>]$,5/$-$?!#

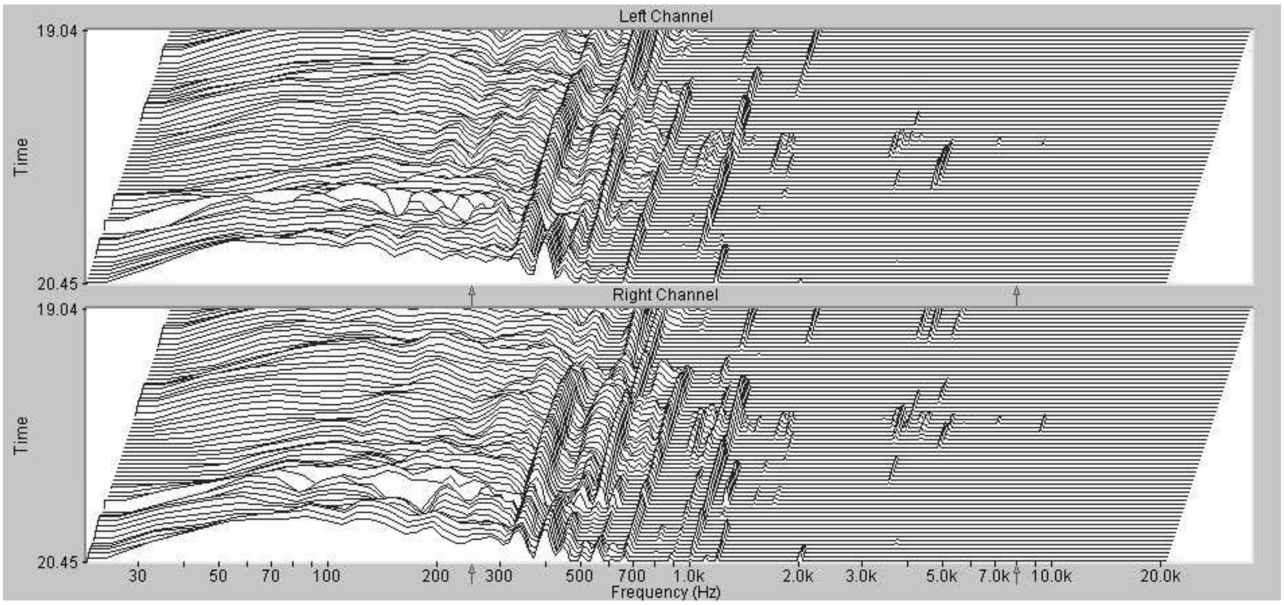
4.2 #R#S#S(Roland Sound Space Processor) HNHf3S

RSS %7%9%F%`$O!"J}8~46!"5wN%46!"NW>146$r=hM}$9$k@1MQ$N%W%m%;%C%5$rEk:\$7$F$$$k!#$=$NJ+GbJ}8~46$r=hM}$9$k%P%$%N!<%i%k%W%m%;%C%5$O1 %A%c%s%M%k$N?.9f$r%G%#%8%?%k?.9f=hM}$KhC$F!"%P%$%N!<%i%k%5%&%s%I$KJQ49$9$k!#2>O$N3D %5%&%s%I$NCN3P$G@bL@7?!":81&$N<*$KE~C#9k2;$N;~4V:9$d<~GH?tFC@-KhCF3D %5%&%s%I$r@8@.$9$k[16]!#<B:]$KRSS $rMQ$$$F:n@.7?H-$NRSS $N%7%9%F%`9=@.$r?^29$K<($9!#?^30!"31$O4>O$HF1MM$K3-D %5!<%U%'%$%9$GI=<($7$?$bNG$"$k!#

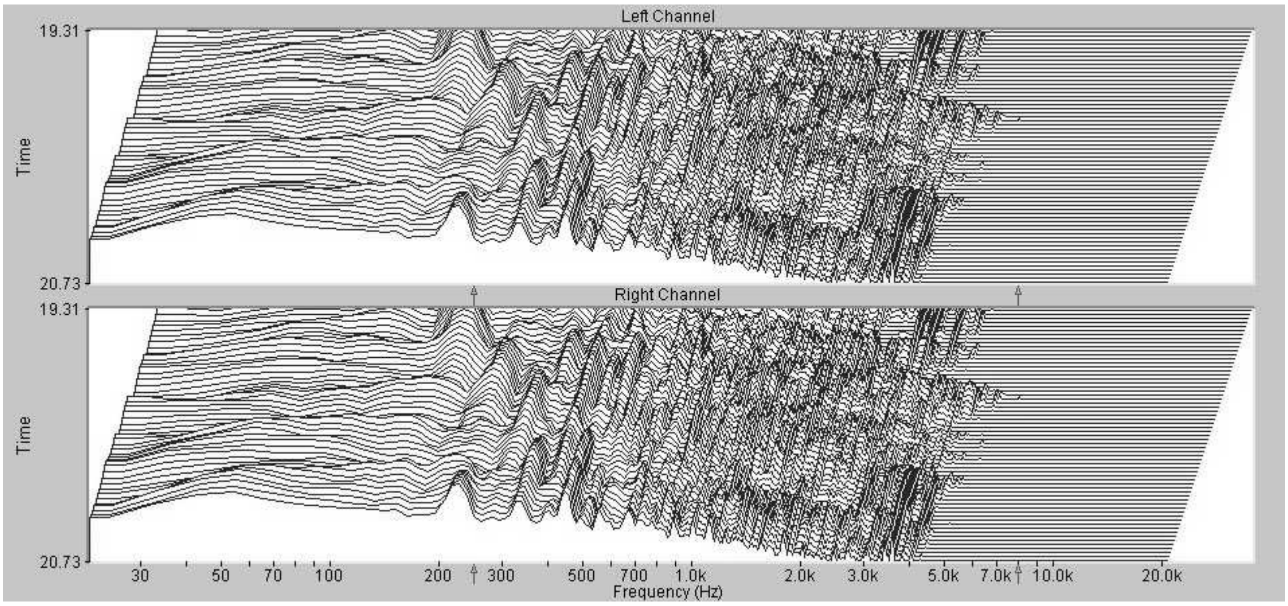


?^29: RSS $N%7%9%F%`9=@.

?^30!"31$rHf3S$9kH@8@.7?N>J}Hb9b<~GH?tNN0h$KJ,I[$7$F$$$J$$$3H,o+$k!#$7$+$7!"Dc<~GH?tNN0hKN2;05%1%Y%k$,9b$$$H$$$&0c$$$"k?$a!"2;$,3d1F7^$&$,3D %5%&%s%I$N8z2L$,>/$7=P$?$H9M$($k!#



?^30: RSS $NGH7A



?^31: @8@.7?3D %5%&%s%I$NGH7A

5 $*$ojK

K\O@J8GO!"=>Mh$N%9%F%l%*:F@8$H0[Jk3D %5%&%s%I@8@.5;=Q$KCmL\$7!"3D %5%&%s%I@8@.KD$$$F$N@bL@$H!"$=$N3D %5%&%s%I8z2L$r%Q!<%=%J%k%3%s%T%e!<%?>e$G<B8=$9$k3D %5%&%s%I@8@.%7%9%F%`$N9=C[$r9T$C$?!#$^$?!"%7%9%F%`$NI>2AJ}K!$r9M$(<B83$r9TC?!#

:#2s9=C[7?3D %5%&%s%I@8@.%7%9%F%`$O!"2;6A%7%_%e%l!<%7%g%s$H$$$&5;=Q$KJ,N`5l$k!#2;$N6A$-$NMWAGG"$k%$%s%Q%k%91~Ez$r>v$_9~$_7W;;$9k3HG!"$=$N6A$+$;$F$$$?It20$r:F8=$9k?$a!"%$%s%Q%k%91~EzNB,Dj,0lHV=EMWG"k3H,o+C?!#

8=;~E@GO!"RSS hj:n@.5l$?3D %5%&%s%I$rMQ$$$!"$=$l$r%$%s%Q%k%91~Ez$K8+$?N)FF;HMQ$7<B83$r9TCF$$$k!#$$$m$$$m$J%$%s%Q%k%91~Ez$rMQ0U$7<B83$r9T$C$F$$$k$,!"3NN)$7$?3D %5%&%s%I$,@8@.5l$J$$!#%$%s%Q%k%91~Ez$OK\%7%9%F%`NMWG$"$j:#8e$=$NB,Dj$,IT2D7g$G$"$k$H9M$($k!#

<U<-

K\8&5f$N5!2q$rM?$($F$/$@5j!"?t!9$N=u8@$*hS?F@Z$J;XF3$rD:$-$^7?!";3:j>!90 65<x$K?<$/46<UNOUrI=7^$9!#$^$?$3l^$G$$$m$$$m$J=u8@$rD:$-$^7?8&5f<<$N3'MM $K46<UCW$7$^$9!#

; 29MJ88 %

[1] EE; R>pJsDL? .3X2qJT ! 2 ;6A%7%9%F% `$H%G%#%8%?%k=hM}, %3%m%J<R(1995).

[2] F |K\2 ;6A3X2qJT ! 2 ;$N%3%_%e%K%1!<%7%g%s9)3X, %3%m%J<R(1996).

[3] The Bose Professiona Sound Grou ! %5%&%s%I%7%9%F% `%G%6%$%s, %*!<% `<R(1991).

[4] Don and Carolyn Davis ! %5%&%s%I%7%9%F% `% (%s%8%K% "%j%s%0, @?J8F2?78w<R(1992).

[5] @uLn=cLi ! ':G?7#3#D%5%&%s%I; v>p, %"%9%-!<No.230,pp.342-347(1996).

[6] 9bLn2m=U, 2CF#2m9@, 2,ItNOLi ! <!@$Be%*!<%G%#%*$NK(2j! "2 ;>1@)8f, F |7P% (%1%/%H%m %K%/%9,No.459,pp.100-115(1988).

[7] FqGH@ :0 1O: ! 2 ;$N2J3X, D+AR=qE9(1989).

[8] C+2 .N4; L ! 2 ;@<$H2hA |$N%G%#%8%?%k? .9f=hM}, %3%m%J<R(1996).

[9] 0KC#=SI', ?aLnH~OB, >.@nM};R, @nB<L@5W ! N)BN2 ;6AAG: `@) :n%D!<%k, >>2<5; Js,Vol.42,No.5,pp.615-621(1996).

[10] CfEDOBCK ! 2 ;@<, F |K\2 ;6A3X2qJT 2 ;6A9)3X9V:B(1995).

[11] @DLZLPL@ ! D03P$+$i8+$?2 ;6A@_7W, F |K\2 ;6A3X2q; o,Vol.53,No.9,pp.749-753(1997).

[12] @>N4; J ! ':G6a$N2 ;>1%P!<%A%c%k%j%"%j%F%#%7%9%F% `KD$$$F, F |K\2 ;6A3X2q ; o,Vol.51,No.12,pp.965-970(1995).

[13] Eb_7@? ! 2 ;$N2J3X$U7 .<-E5, F |K\<B6H=PHG<R(1997)

[14] 9b66; KCi ! 2 ;>1$r9-$2$k2 ;6A8z2LIC, F |7P% (%1%/%H%m%K%/%9No.661,pp. 127-138(1996).

[15] :42 1? .G7 ! WAV %U%)!<%^%C%H$r2r@O$9$k,OH! FM TOWNS, %=%U%H%P%s%/(1994 !K

[16] ?70f=c ! How To Make The True 3D Sound by RSS-10, %m!<%i%s%I3t<02q<R(1997)

[17] 2#0fM?<!O: ! Visual C++5.0 %Q%o!<%W%m%0%i%_%s%0, %=%U%H%P%s%/(1997)

[18] Scott Stanfield ! "Ralph arvesen ! Visual C++ 5 %Q%o%U%k%F%/%K%C%/BgA4=8, %$%s%W%1 %9(1997)