



Software Development Seminar

Sound (Basic)



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SPU Architecture Overview



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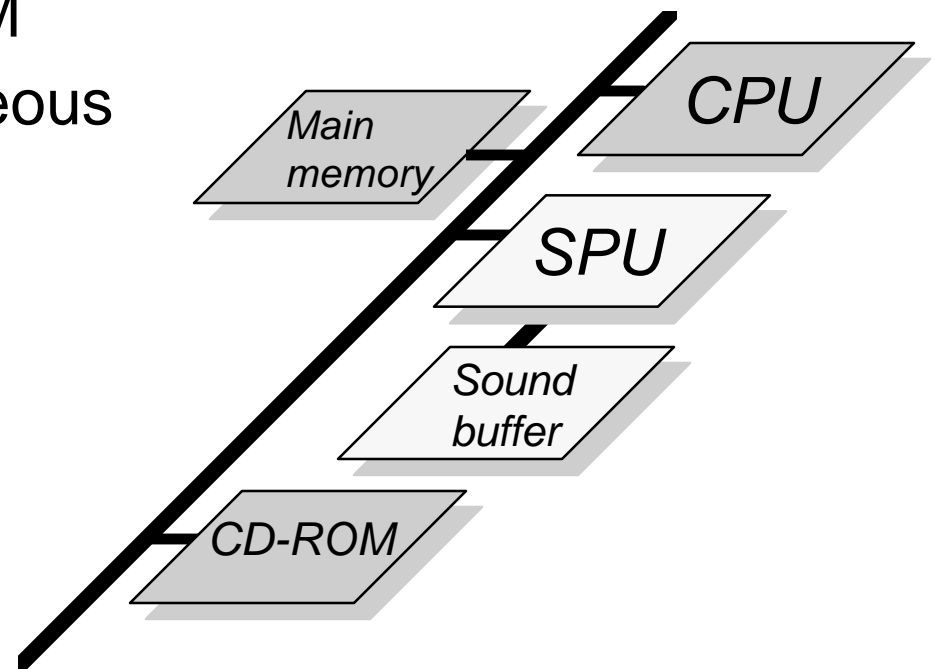
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SPU

Sound Processing Unit

- Data format: ADPCM
- Number of simultaneous sounds: 24
- Sampling frequency: 44.1 KHz
- Sound buffer: 512KB (4Mb)

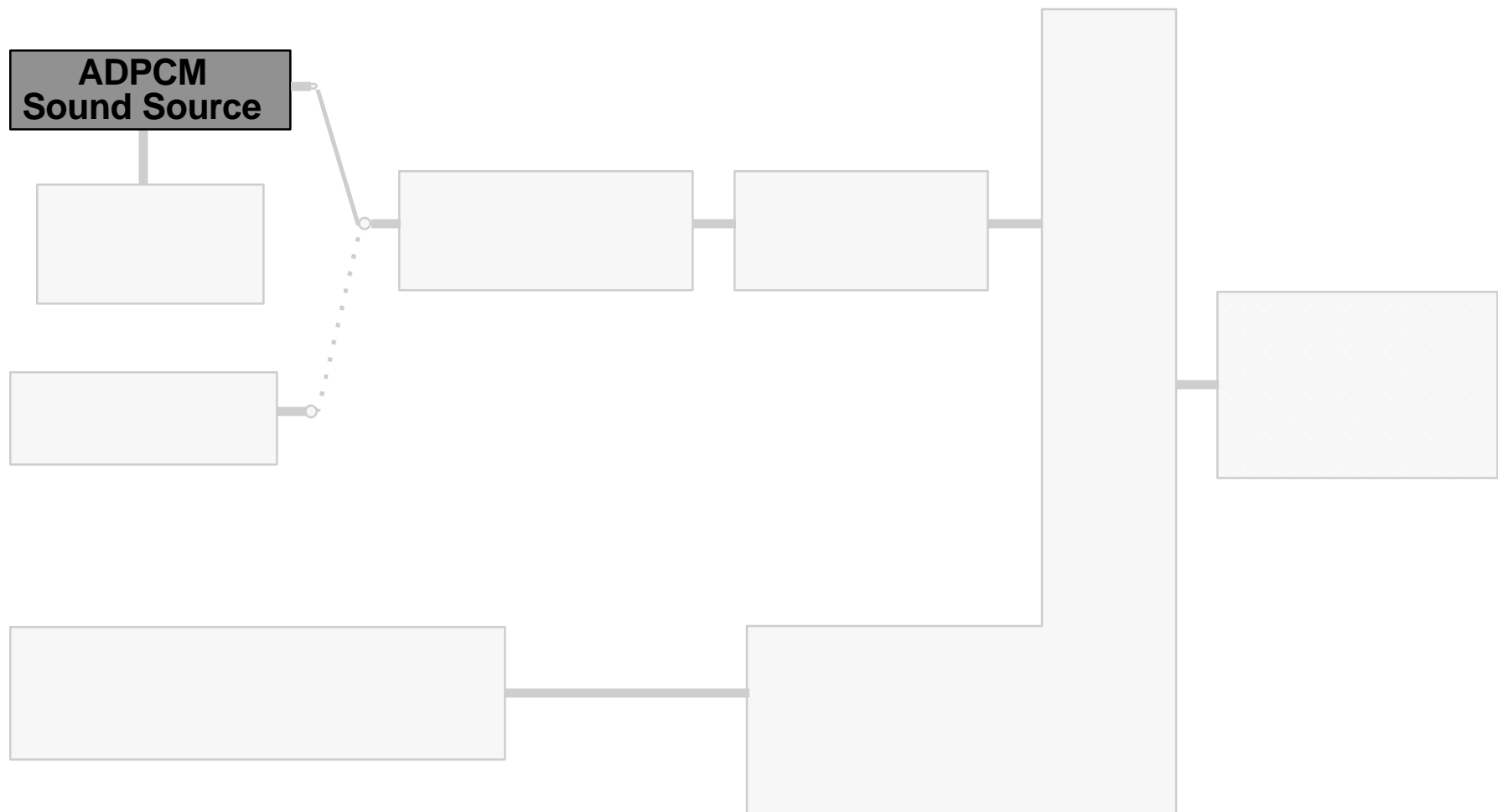


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ADPCM sound source



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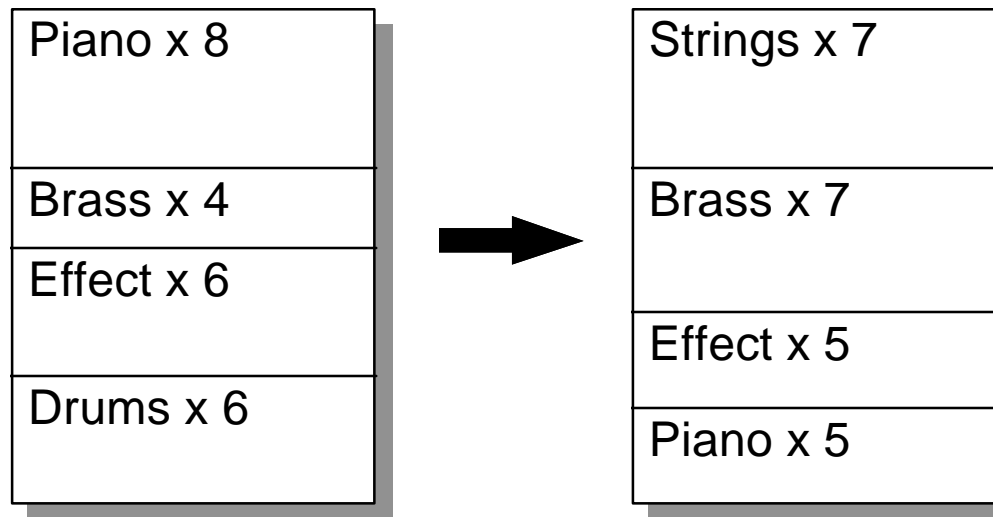
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ADPCM sound source (cont)

ADPCM Sound Source

- Number of simultaneous sounds: 24
- Can set waveform data individually
- Can control attributes individually



Pitch setting

Pitch Setting

Can generate sound with varying waveform data interval

Range: -12 oct. ~ 2 oct.

Resolution: Can specify fine intervals
of a halftone or less



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LFO

Pitch LFO

When two voices are adjacent, it is possible to apply modulation to the pitch of one voice even if the other voice's volume is undergoing time changes

$$\text{NewPitch}_n = (1 + V_{n-1}) \text{Pitch}_n$$

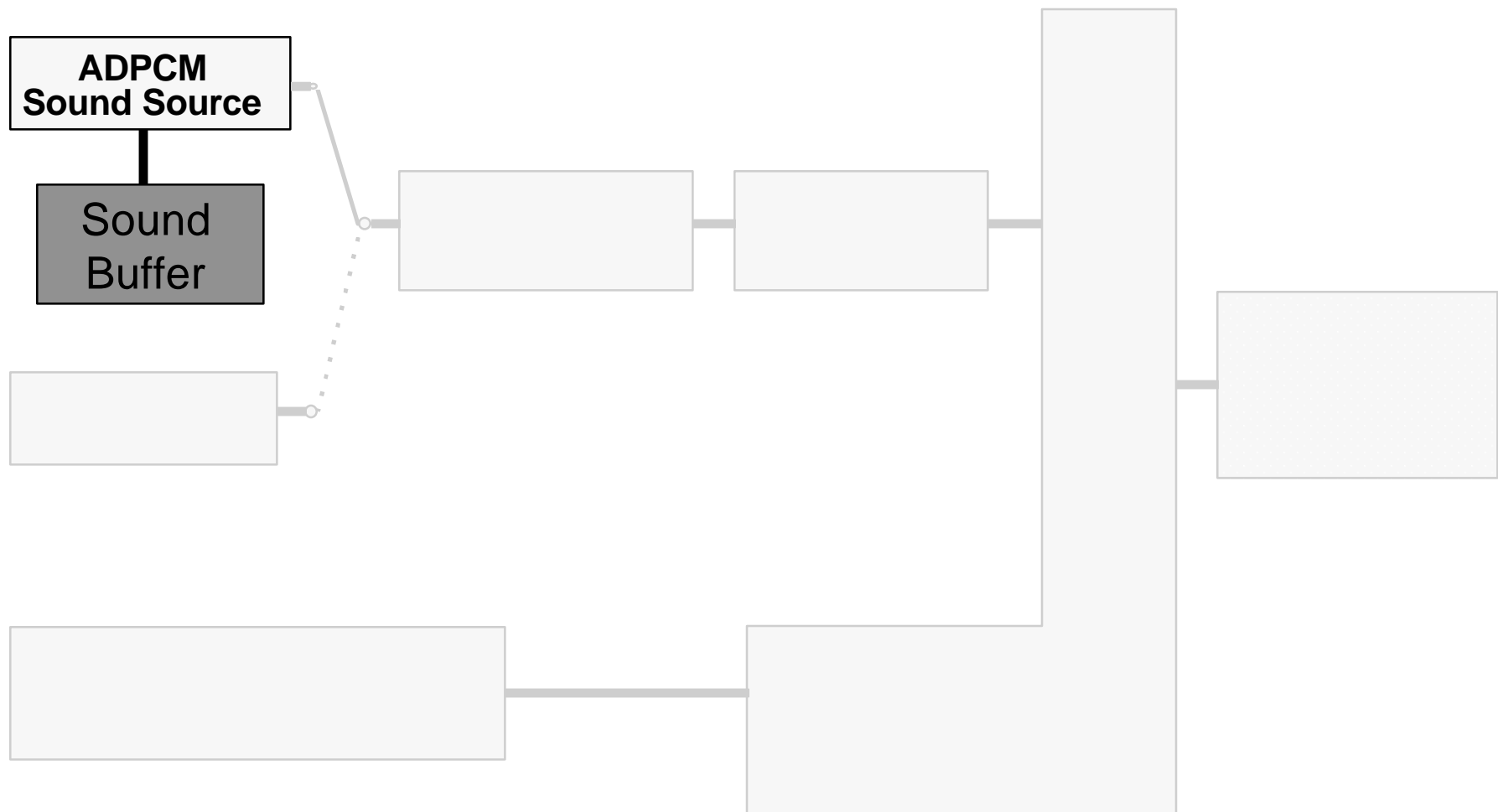
NewPitch_n : Final pitch of voice(n)

Pitch_n : Pitch of voice(n)

V_{n-1} : Volume of voice(n-1)



Sound buffer (1)



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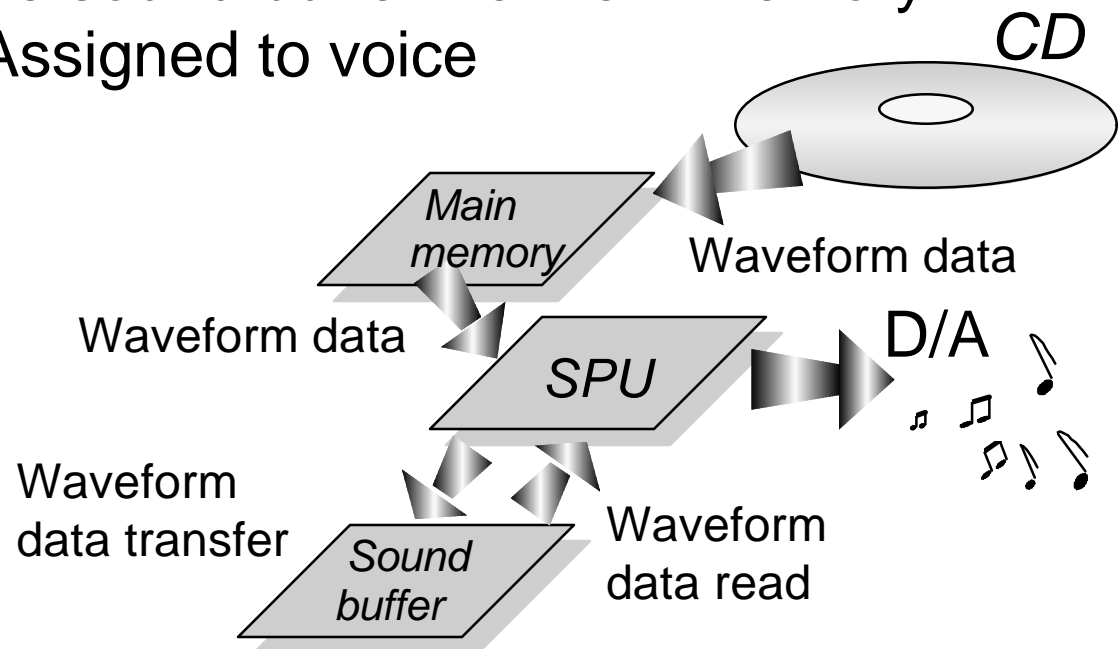
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Sound buffer (2)

Sound buffer

Capacity : 512KB (4Mb)

ADPCM waveform data is transferred
to the sound buffer via main memory
→ Assigned to voice



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Sound buffer (3)

Transfer systems

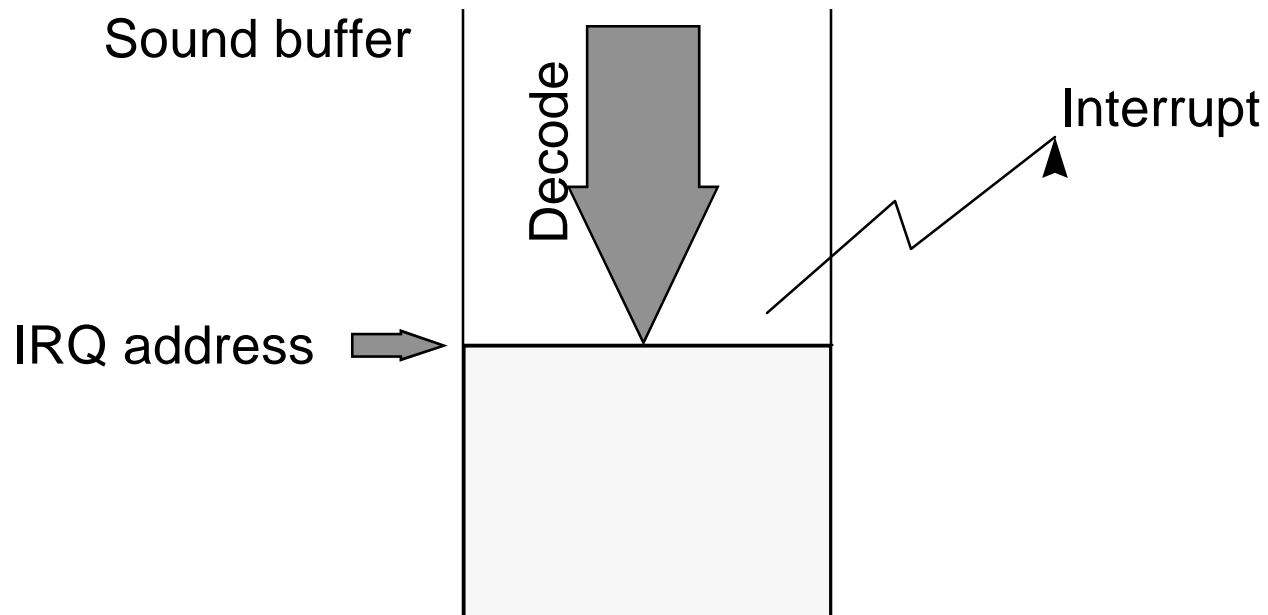
- DMA transfer
- I/O transfer
(Main memory → sound buffer only)



Interrupt from SPU

Interrupt from SPU

Can set address 1

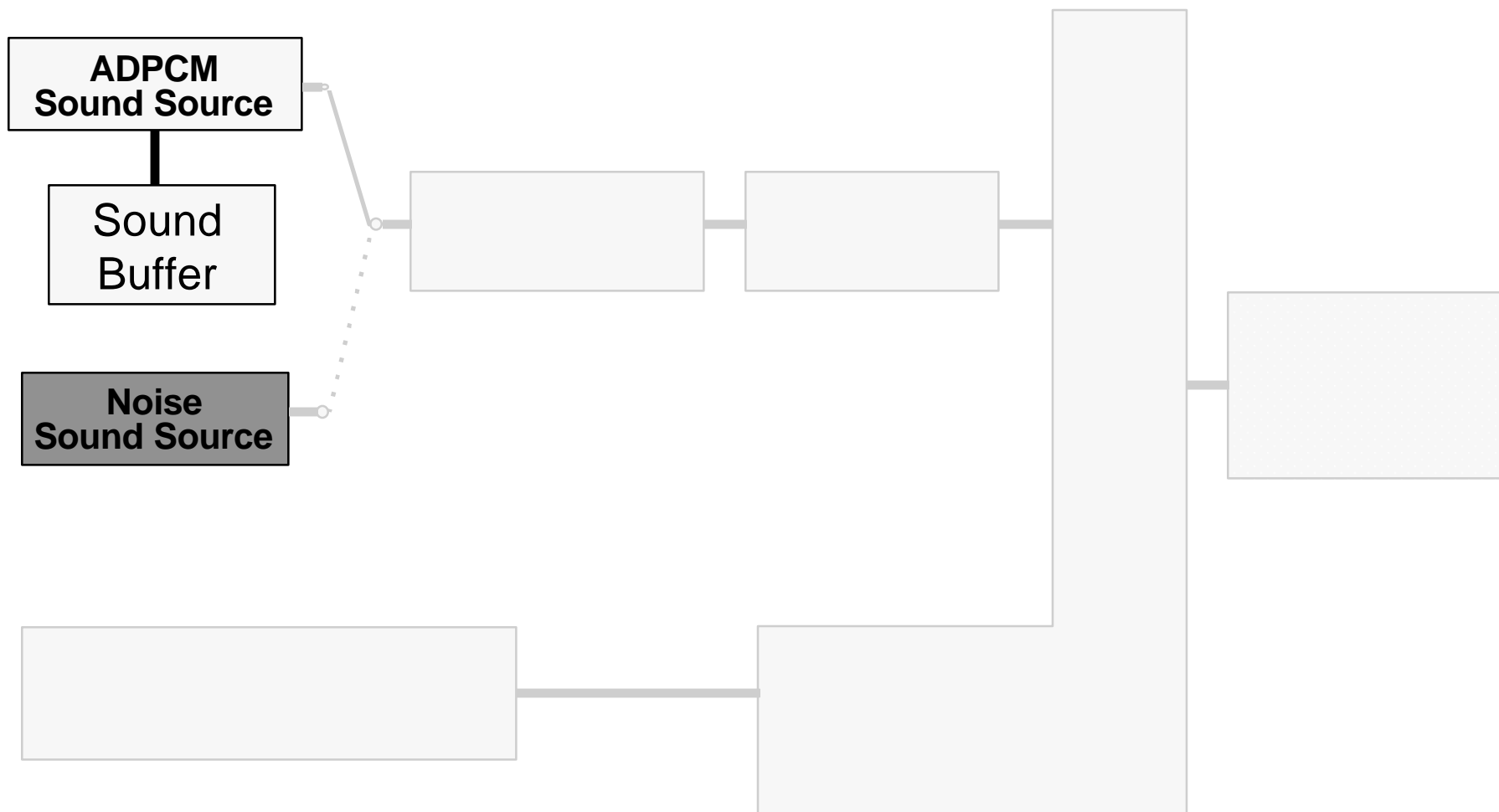


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Noise sound source



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Noise sound source (cont)

Noise sound source

One noise generator is built in

- Can set instead of waveform data
- Can be assigned to more than one voice
- Only one audible pitch can be set

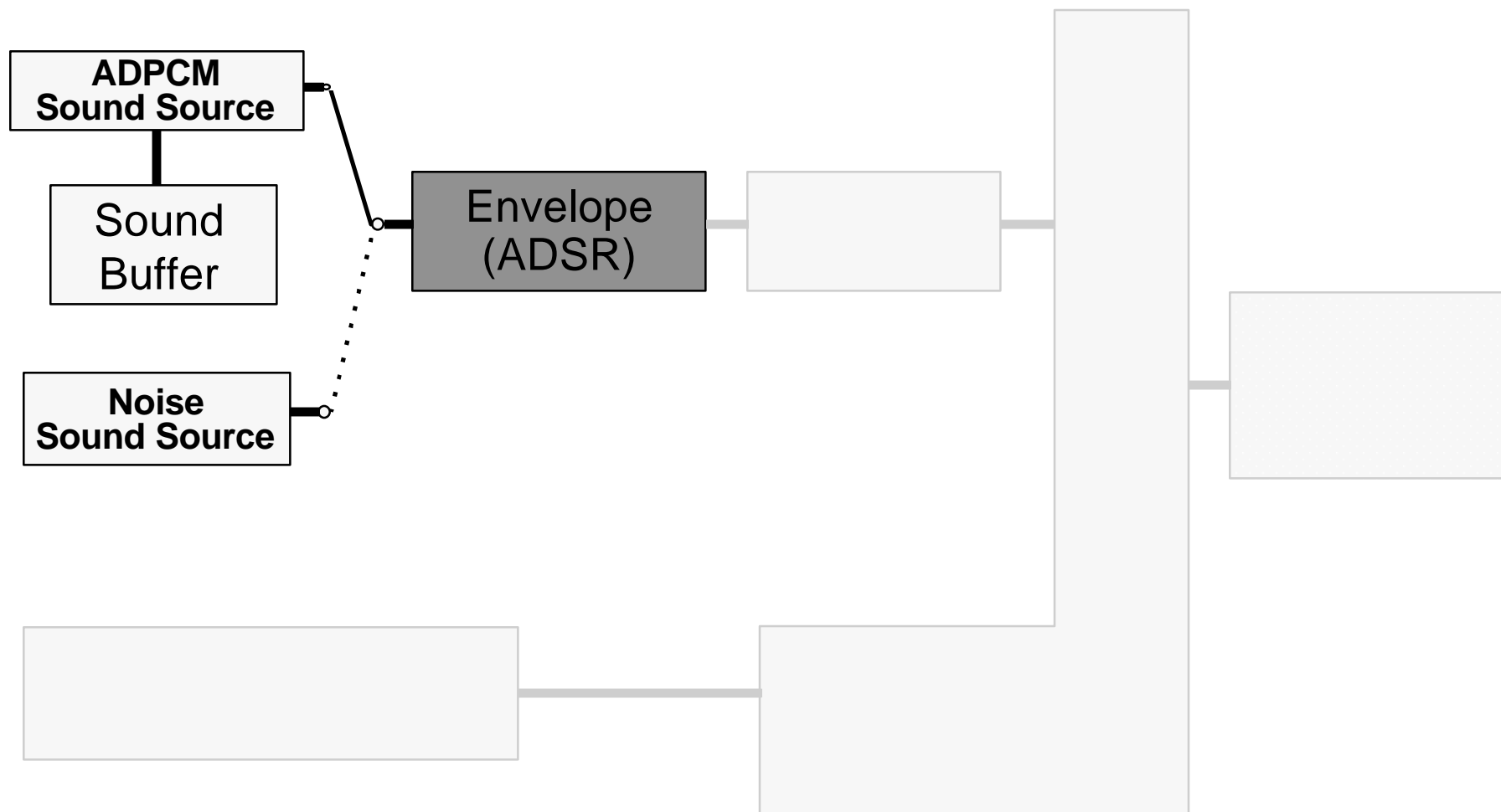


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Envelope / ADSR



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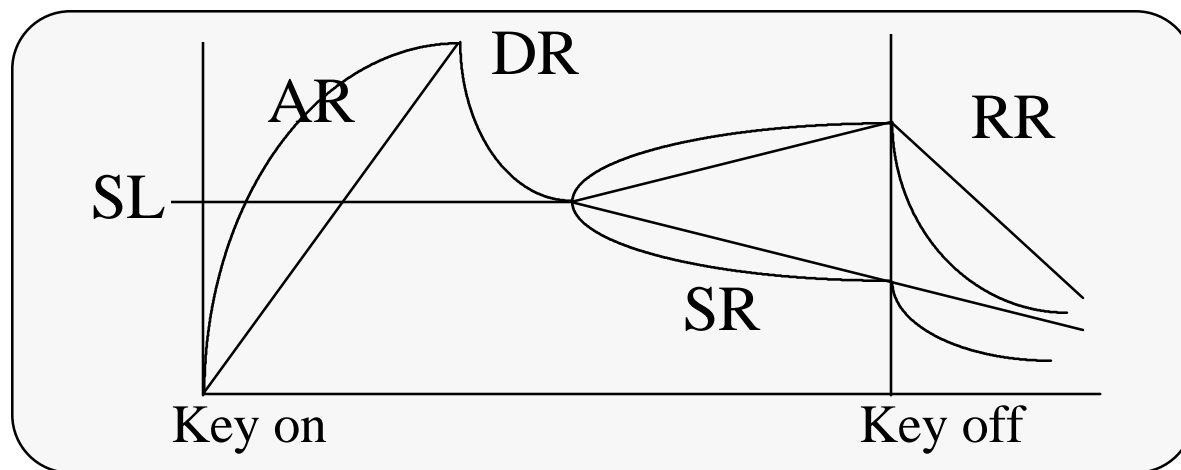
Envelope / ADSR (cont)

Envelope (ADSR)

Rate (speed) can be set for A, D, S, R respectively
Level (volume) can be set for sustain

rate curves

- Linear variation
- Exponential variation

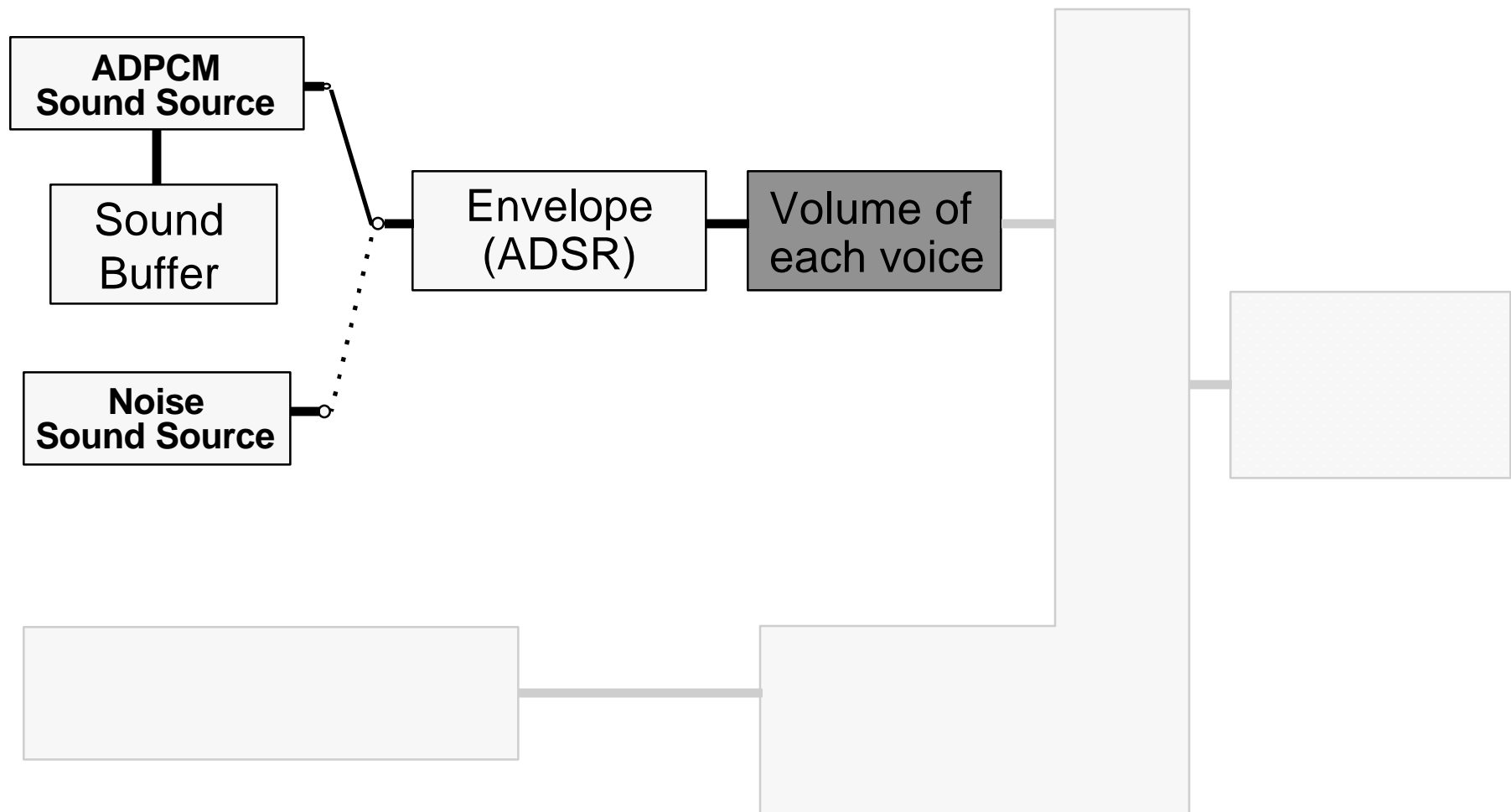


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Volume of each voice



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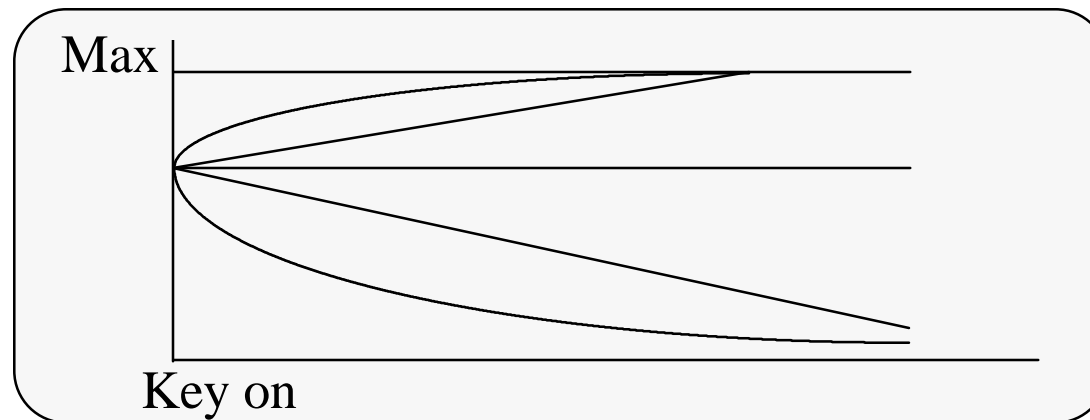
Volume of each voice (cont)

Volume of each voice

Time variation can be set independently of envelope

Curve characteristics

- Fixed value
- Linear variation
- Exponential variation

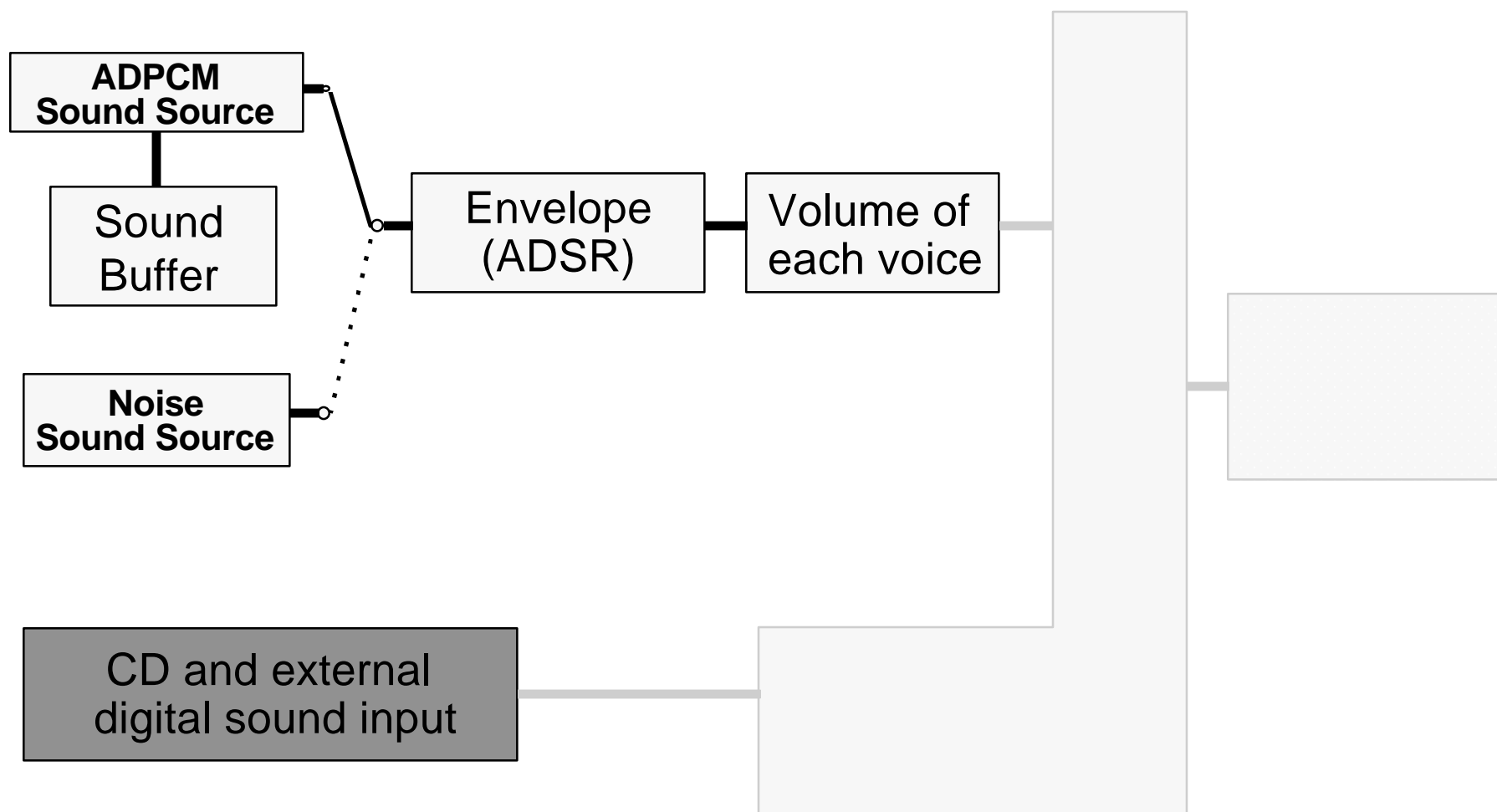


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CD and external digital sound input (1)



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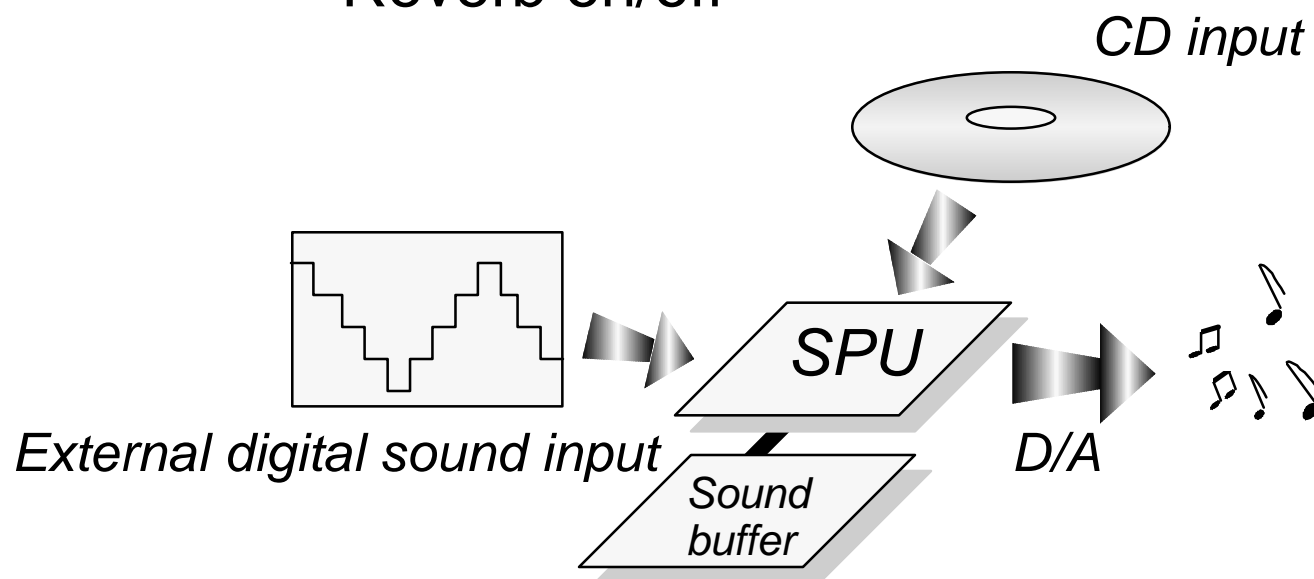
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CD and external digital sound input (2)

CD and external digital sound input

Can mix via SPU

- Mixing on/off
- Mixing volume
- Reverb on/off



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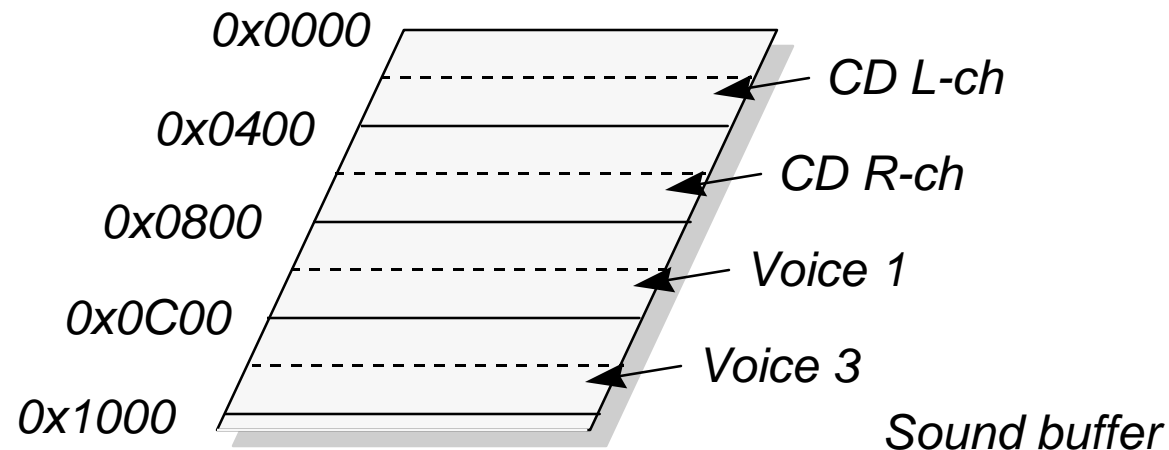
CD and external digital sound input (3)

Feedback sound data to sound buffer

Can get the following data

- Voice 1 and 3 data after envelope processing
- Data before CD volume processing

Data format: 16 bit straight PCM

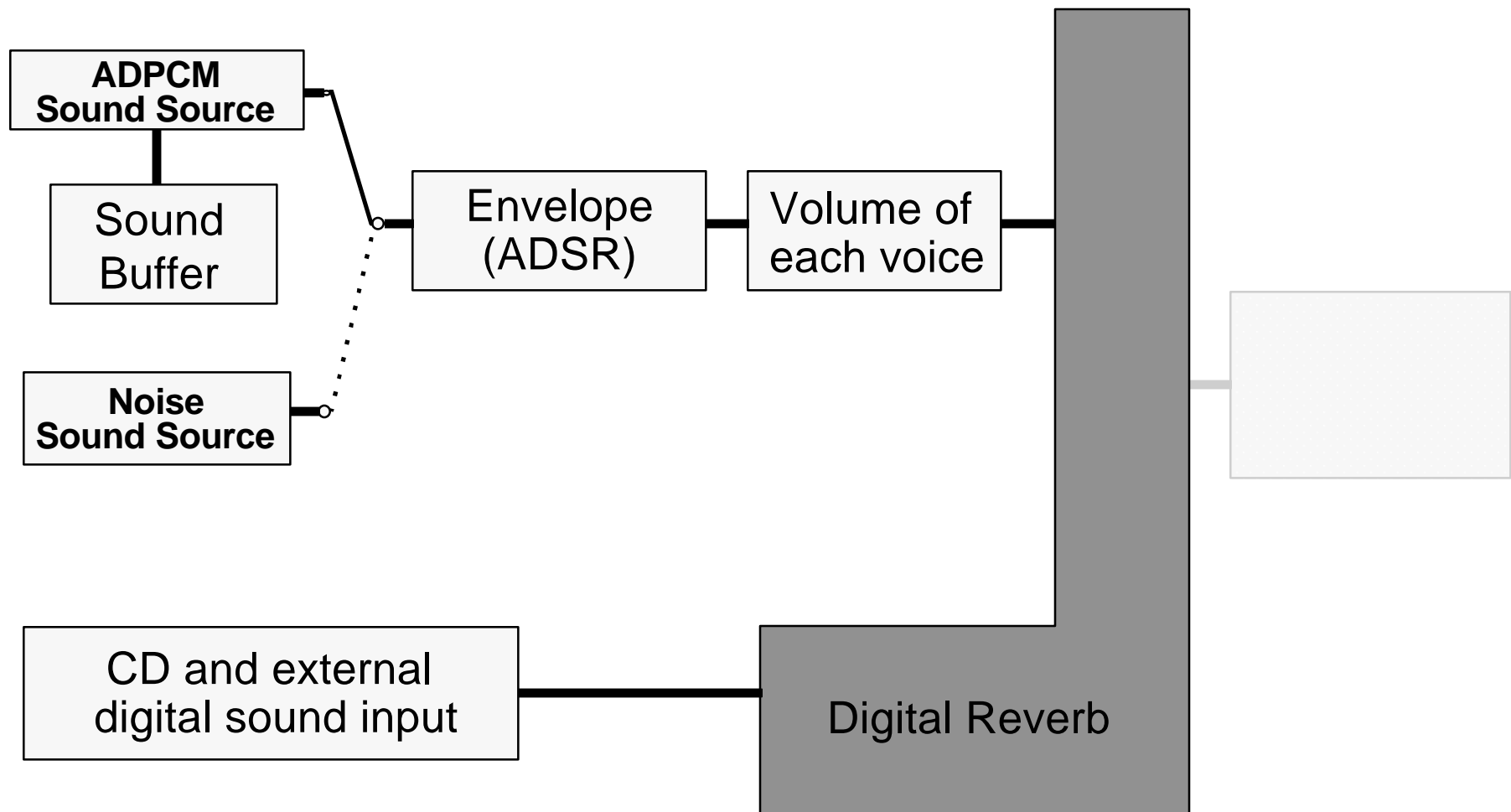


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Digital reverb



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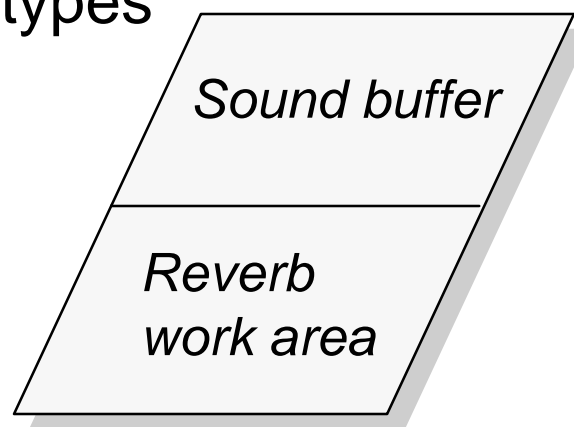
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Digital reverb (cont)

Digital reverb

- The work area can be inside the sound buffer
 - Share with waveform data
- Parameters can use multiple templates at the library side
 - Currently, nine types

Waveform data region :

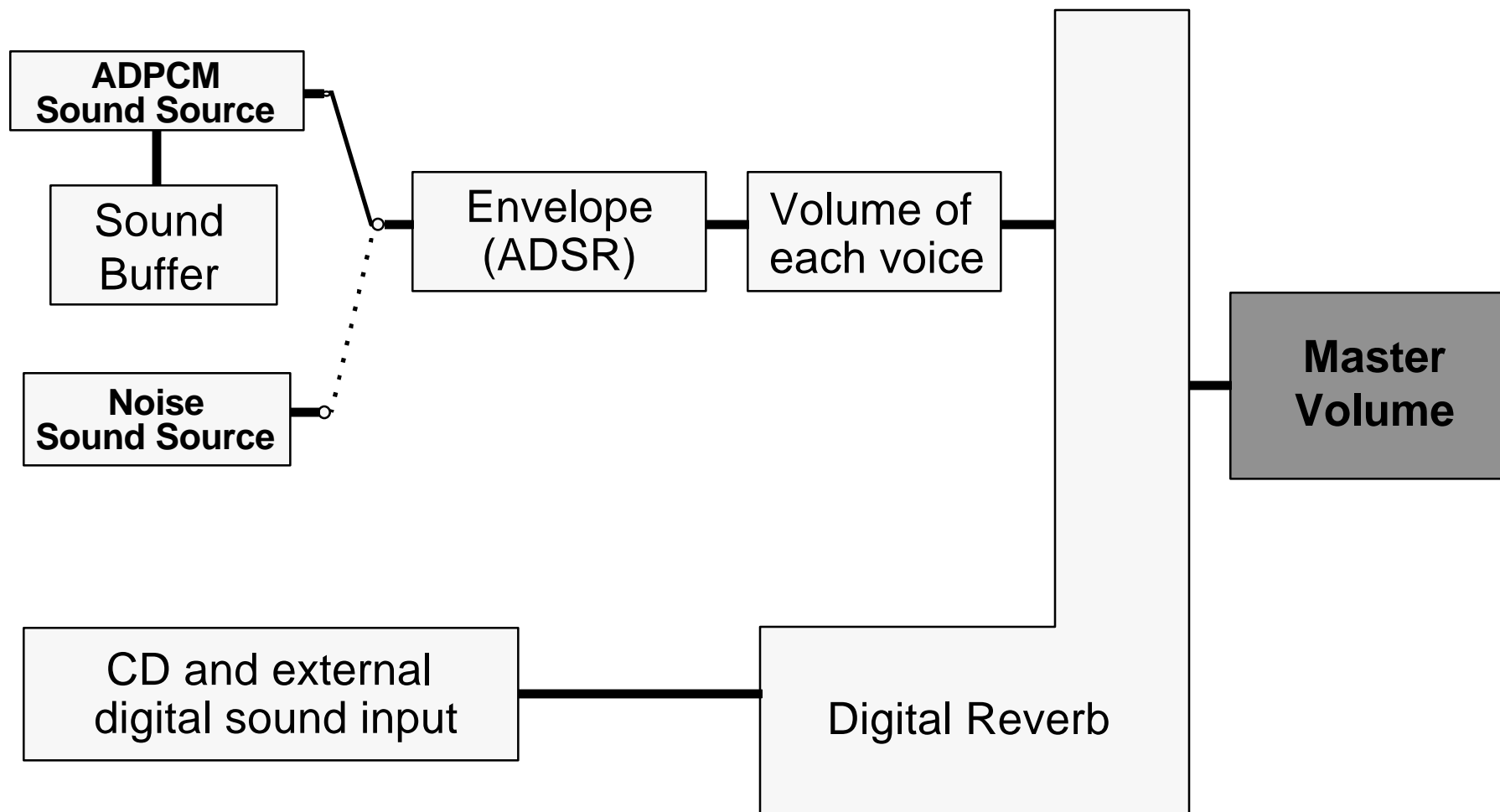


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Master Volume



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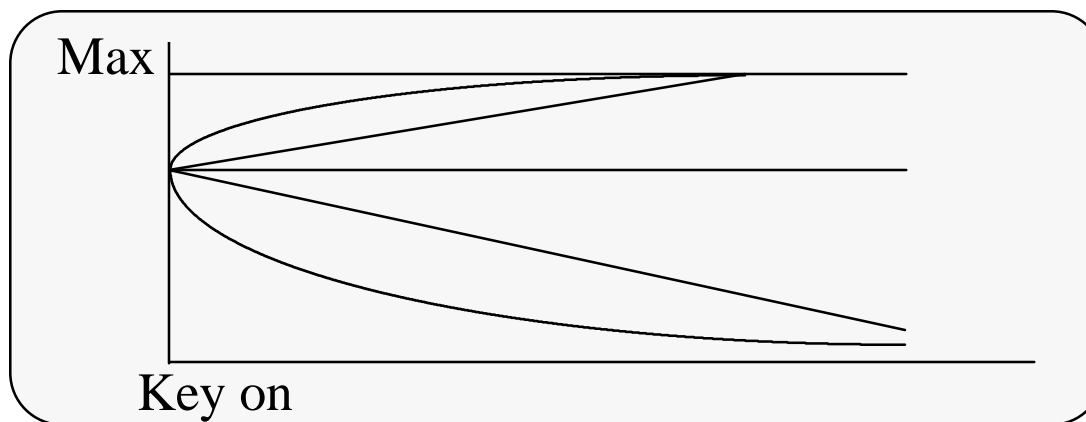
Master volume (cont)

Master volume

Can set time variation in the same way for each voice

Curve characteristics:

- Fixed value
- Linear variation
- Exponential variation

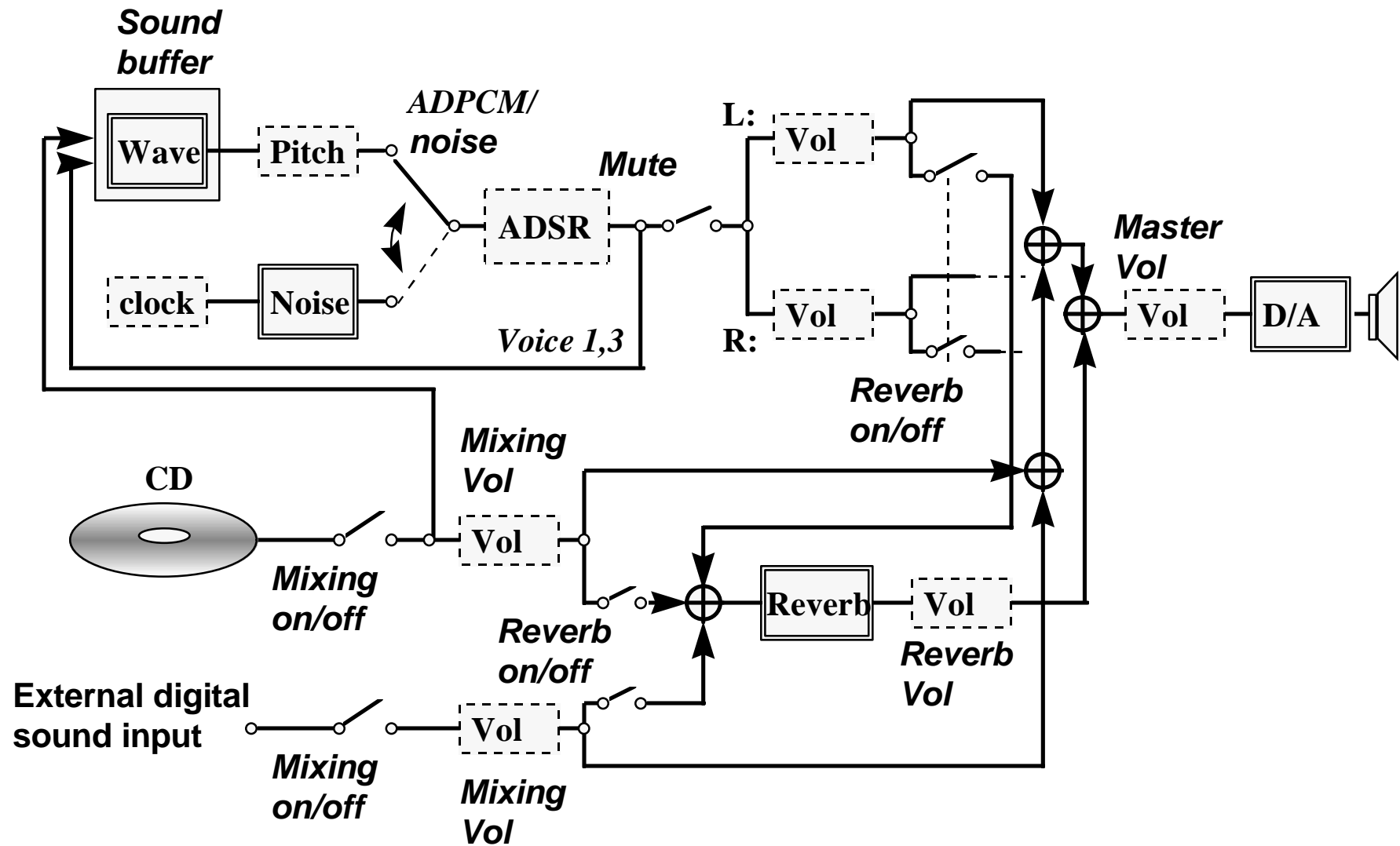


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Signal flow



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Basic Sound Library (Libspu) Overview



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libspu

libspu

Provides the PlayStation's basic sound functions

- Sets each voice's attributes, generates sound, extinguishes sound
- Sets common attributes such as master volume, reverb, etc.
- Sound buffer and main memory data transfer
- When there's an SPU interrupt, supports callback function when DMA transfer ends



Functions not supported by libspu

Functions not supported by libspu

- Sequence processing
- Effects accompanying time operations
 1. Vibrato, pitch bend, portamento
 2. Fade in, fade out, etc.
- Strategies for solving this
 1. Use expanded sound library (libsnd)
 2. Use and create kernel library (libapi)



Initialization/end

Initialization/end

SpuInit()

[**SpuStart()**

[**SpuQuit()**

Initialize SPU

Start SPU processing]

End SPU processing]



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Common attributes

Common attributes

SpuSetCommonAttr()

Set common attributes for all voices

SpuGetCommonAttr()

Get common attributes for all voices

SpuSetMute()

Sound mute on/off

SpuGetMute()

Get status of sound mute



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Each voice (1)

Each voice

Each attribute

SpuSetVoiceAttr()	Set attribute of each voice
SpuGetVoiceAttr()	Get attribute of each voice
SpuSetKey()	Set key on/key off for each voice
SpuSetKeyOnWithAttr()	Set key on with attribute for each voice
SpuSetReverbVoice()	Set reverb on/off for each voice
SpuGetReverbVoice()	Get reverb on/off for each voice



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Each voice (2)

Noise Sound Source

SpuSetNoiseVoice()

Set noise sound source on/off for each voice

SpuGetNoiseVoice()

Get noise sound source on/off for each voice

SpuSetNoiseClock()

Set noise sound source clock

SpuGetNoiseClock()

Get noise sound source clock

Pitch LFO

SpuSetPitchLFOVoice()

Set pitch LFO on/off for each voice

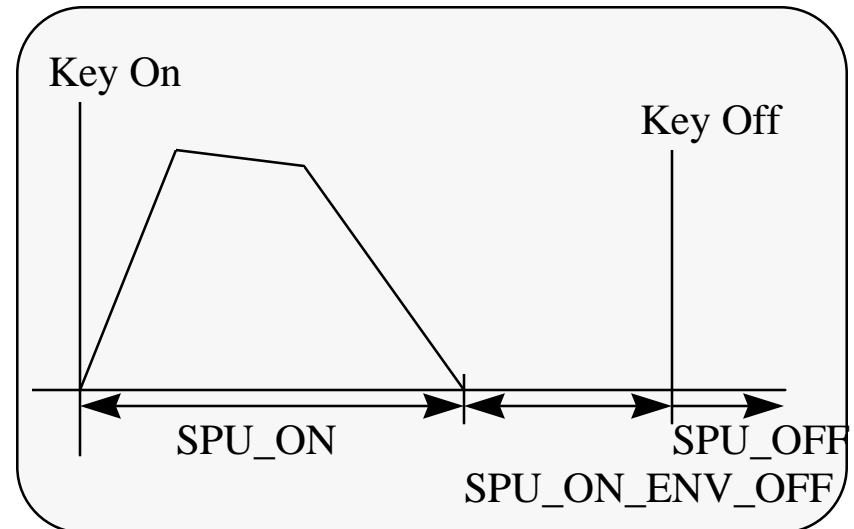
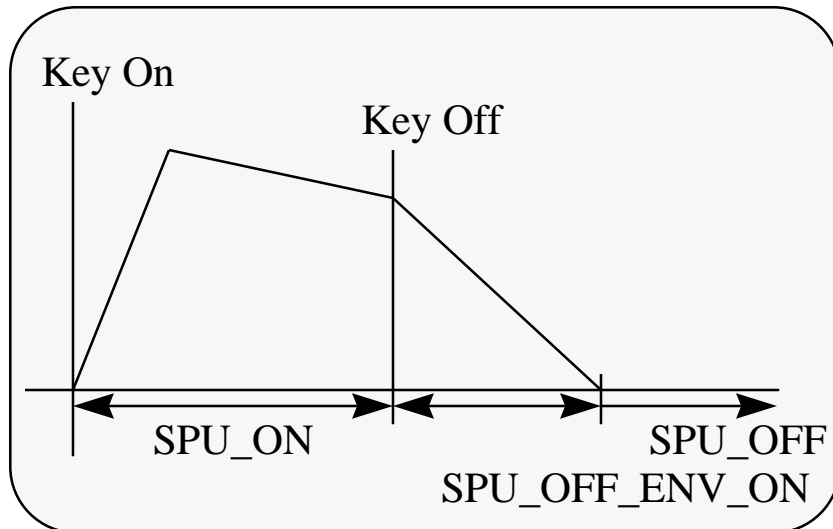
SpuGetPitchLFOVoice()

Get pitch LFO on/off for each voice



Each voice (3)

Key on/key off/envelope status



SpuGetKeyStatus()
SpuGetAllKeysStatus()

Get key on/key off for specified voice
Get key on/key off for all voices



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Data transfer (1)

Data transfer

Transfer

SpuWrite()

**Transfer from main memory
to sound buffer**

SpuWrite0()

Clear sound buffer

SpuWritePartly()

**Transfer from main memory
to sound buffer (assuming
partially divided transfer)**

SpuRead()

**Transfer from sound buffer to
main memory**

SpuReadDecodeData()

**Transfer SPU decoded sound
data from sound buffer to
main memory**



Data transfer (2)

Transfer Address

SpuSetTransferStartAddr() Set sound buffer's transfer destination/transfer source starting address

SpuGetTransferStartAddr() Get sound buffer's transfer destination/transfer source starting address

Transfer Mode

SpuSetTransferMode() Set transfer mode to sound buffer
SpuGetTransferMode() Get transfer mode to sound buffer



Data transfer (3)

Transfer synchronization

SpulsTransferCompleted()

**Get completion of transfer to
sound buffer**

SpuSetTransferCallback()

**Set callback function when
DMA transfer completed**



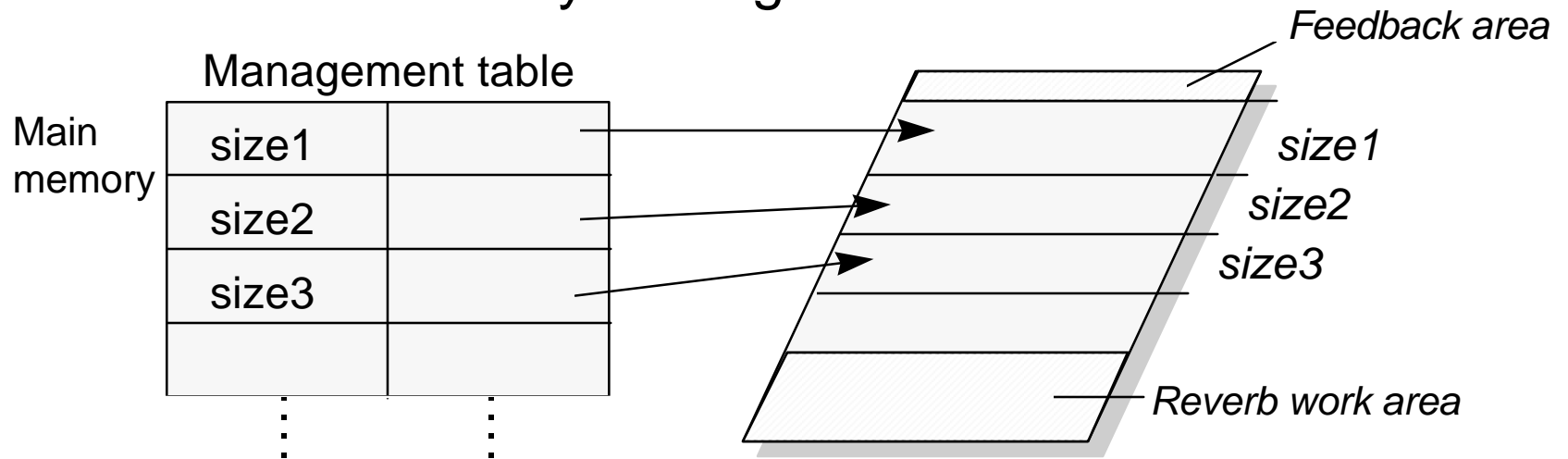
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Sound buffer memory management

Sound buffer memory management



SpuInitMalloc()

Initialize sound buffer memory management mechanism

SpuMalloc()

Reserve area in sound buffer

SpuMallocWithStartAddr()

Reserve area starting from specified address in sound buffer

SpuFree()

Release reserved area in sound buffer



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Reverb

Reverb

Types

Room, studio (small, medium, large), hall,
space echo, echo, delay, half echo

Attributes

SpuSetReverb()

Set reverb on/off

SpuGetReverb()

Get reverb on/off

SpuSetReverbModeParam()

Set reverb mode and parameter

SpuGetReverbModeParam()

Get reverb mode and parameter

SpuSetReverbDepth()

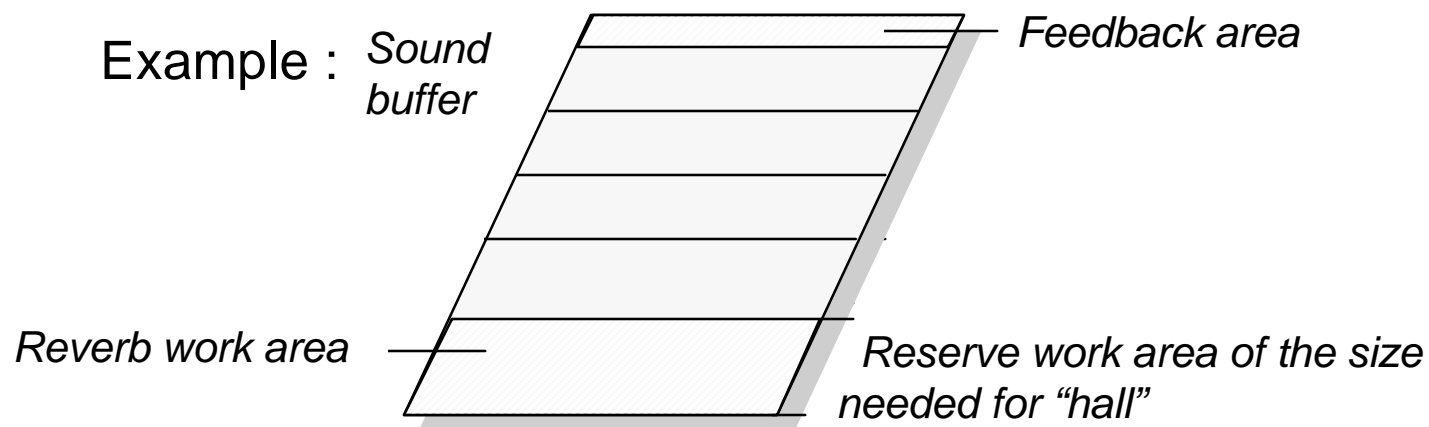
Set reverb depth parameter



Reverb (cont)

Reverb work area

- In order to avoid conflicts with data, the size of the work area can be reserved in the sound buffer according to the type of reverb



SpuReserveReverbWorkArea()
SpuIsReverbWorkAreaReserved()

Reserve/release reverb work area
Check if reverb work area is reserved, get whether or not reverb work area can be reserved
Area of reverb work area



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SPU interrupt

SPU interrupt

SpuSetIRQ()

SpuGetIRQ()

SpuSetIRQAddr()

SpuGetIRQAddr()

SpuSetIRQCallback()

Interrupt on/off

Get status of interrupt on/off

Set interrupt address

Get interrupt address

**Set callback function when
interrupt**



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Expanded Sound Library (Libsnd) Overview



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libsnd

libsnd

Structure based on libspu

- Can co-exist with libspu
- Use libapi for time control
 - Can also add changes specified by user
- Transfer of wave data to sound buffer
- Automatic performance of music data



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Sound data format (1)

Score data format

- SEQ format
 - Convert from SMF (Standard MIDI File)
 - Has attributes and notation data needed for playing
 - Resident in main memory
- SEP format
 - SEQ group (up to 16 units can be integrated)
 - Created by SEQ2SEP.EXE in PC



Sound data format (2)

SMF ... realtime processing using NRPN

When SMF is created, the following realtime processing can be done by combining Control Change-NRPN data

- Change VAB attributes data (Reverb, ADSR)
- Set repeat during music
- Marking function
 - Can set callback function at program side



Sound data format (3)

Waveform data format

VAG format

- Convert from AIFF (Audio Interchanged File Format)

VAB format

- VAG group
 - libsnd uses VAB as waveform data
 - Divide into header part and body part using VABSPLIT.EXE in PC
-
- Header part : each VAG's attributes (VH file)
 - Body part : Transfer to sound buffer (VB file)



libsnd controls

Voice manager

- Can explicitly set priority sequence in VAG units in VAB header
- Monitor key on/key off/envelope information
- SEQ/SEP can separate voice used by score data and single sound generated sound (SE)



Initialization / completion

SsInit, SsInitHot

Initialize sound system, hot reset

SsSetTableSize

Specify the area of a SEQ/SEP data attribute table

SsSetTickMode

Set tick

SsSetTickCallback

Set tick (Tick Callback) callback

SsStart, SsStart2

Start the sound system

SsEnd

Stop the sound system

SsQuit

Quit sound system



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VAB access functions

SsVabOpenHead	Recognize a sound source header list
SsVabTransBody	Transfer sound source data
SsVabTransCompleted	Get VAB data transfer state
SsVabTransPartly	Partly transfer sound source data
SsVabOpenHeadSticky	Recognize a sound source header list
SsVabFakeHead	Recognize a sound source header list (re-recognition)
SsVabFakeBody	Set up a library using the sound source data in the sound buffer as the given VAB ID (no transfer)
SsVabClose	Close VAB data file



SEQ/SEP access functions

SsSeqCalledTbyT	Interpret SEQ data and carry out playing, called at each 1 tick
SsSeq(SsSep)Open	Open SEQ/SEP data
SsSeq(SsSep)Close	Close SEQ/SEP data
SsSeq(SsSep)Play	Read (play) SEQ/SEP data
SsSeq(SsSep)Pause	Pause the reading of SEQ/SEP data
SsSeq(SsSep)Replay	Resume (replay) the reading of SEQ/SEP data
SsSeq(SsSep)Stop	Pause the reading of SEQ/SEP data
SsSeq(SsSep)SetCrescendo	Crescendo
SsSeq(SsSep)SetDecrescendo	Decrescendo
SsSeq(SsSep)SetRitardando	Slow the tempo
SsSeq(SsSep)SetAccelerando	Accelerate the tempo



SEQ/SEP access functions (cont)

SsSeq(SsSep)SetVol	Set SEQ/SEP volume
SsSeqGetVol	Obtain SEQ /SEP volume
SsSeqSetNext, SsSetNext	Specify subsequent SEQ data
SsPlayBack	Read SEQ/SEP data
SsSetTempo	Set a tempo
SsSetLoop	Set a song repetition count
SsIsEos	Determine whether or not a song is being played
SsSetMarkCallback	Register a function to be called when a mark is detected
SsSetReservedVoice	Declare the number of voices to be allocated by libsnd library



Independent controls, common attributes / acquisition functions

SsVoKeyOn(Off)	Key on (off)
SsSet(Get)MVol	Set (get) main volume
SsSet(Get)RVol	Set (get) reverb volume
SsSet(Get)SerialAttr	Set (get) serial input line attribute
SsSet(Get)SerialVol	Set (get) serial input line volume
SsSet(Get)Nck	Set (get) noise clock value
SsSetMute	Set a mute
SsSetNoiseOn(Off)	Set noise on (off)
SsSetMono	Set monaural mode
SsSetStereo	Set stereo mode
SsSetAutoKeyOffMode	Set automatic KeyOff mode



Utility functions

SsUtKeyOn(Off)	Key on (off) voice
SsUtKeyOnV(OffV)	Key on (off) voice specified by voice number
SsUtPitchBend	Apply a pitch bend
SsUtChangePitch	Change pitch
SsUtChangeADSR	Change ADSR
SsUtSet(Get)VabHdr	Set (get) VAB attribute header
SsUtSet(Get)ProgAtr	Set (get) program attribute table
SsUtSet(Get)VagAtr	Set (get) tone attribute table
SsUtSet(Get)VVol	Set (get) voice volume
SsUtSet(Get)DetVVol	Set (get) detailed value of voice volume
SsUtAutoVol (not supported)	Automatically change voice volume
SsUtAutoPan (not supported)	Automatically change panning



Utility functions (cont)

SsUtReverbOn(Off)	Turn on (off) reverb
SsUtSet(Get)ReverbType	Set (get) reverb type
SsUtSetReverbDepth	Set reverb depth
SsUtSetReverbFeedback	Set feedback volume
SsUtSetReverbDelay	Set delay volume
SsUtAllKeyOff	Key off all voices
SsUtKeyOnV(OffV)	Key on (off) voice specified by voice number
SsUtFlush	Execute KeyOn/KeyOff requests that have been queued
SsUtGetVBaddrInSB	Return address inside sound buffer to which VAB data specified by VAB id has been transferred
SsUtGetVagAddr	Return a tone attribute table
SsUtGetVagAddrFromToneAuto	Return SPU buffer address where VAG data is stored



Sound Artist Tool Overview



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Sound artist tool

- Tool structure
- Hardware
- Software
- Operating environment
- Sound data creation procedure
- Playing



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Sound artist structure

Hardware

Sound Artist Board - DTL-H700

Software

Sound Artist Tool Version 1.0 - DTL-S710



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DTL-H700 hardware

Sound Artist Board

- PlayStation sound processor: SPU
- Waveform memory: 4 Mbit DRAM
- Sampling frequency (fs): 44.1 KHz
- Optical disk output



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DTL-S710 software

Sound Artist Tool Version 1.0

- Sequence data converter - SMF2SEQ
- Waveform data converter - AIFF2VAG
- Sound source bank editor,
 sound board driver - SoundDelicatessen
- DA and XA data converter
 - RAW2DA
 - RAW2XA



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Operating environment

PowerMac / Mac Quadra / Mac II series (NuBus)

Applicable OS : KanjiTalk7 or higher

Required memory : 8 MB or more (2 MB empty)

D/A converter with optical input (DAT, etc.)

Playing equipment with amp and speaker, etc.



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Sequence data converter - SMF2SEQ

Applicable format

Standard MIDI file (Format 1)

Applicable statuses

Note On / Note Off / Program Change /
Pitch Bend

Applicable controls

Bank Change / Modulation / Panpot /
Main Volume / Expression / Damper Pedal /
External Effect Depth / NRPN Data /
RPN Data / Reset All Controllers

Output

SEQ file



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Waveform data converter - AIFF2VAG

Applicable data format

AIFF file

Optional sampling rate

Resolution fixed at 16 bits

Monaural

Loop (marker) responsive

Output

VAG file



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Sound source bank editor - SoundDelicatessen

Applicable format

VAG files and SEQ files

Output

VAB files

Program (max. 128 types)

Tone (max. 16 types per one program)

VAG (max. 254 types)

Sound board driver function

VAG single-sound play (can specify pitch)

SEQ play



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DA,XA data converter - RAW2DA,RAW2XA

- Applicable data format
16bit straight PCM
(SoundDesignerII format)

DA

44.1KHz Stereo

XA

37.8KHz Stereo
Monaural
18.9KHz Stereo
Monaural

- Output
DA file
XA file → to MovPack (movie tool)



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Sound data creation schedule

- Create SEQ
 - Create VAG
 - Create sound source set
 - Check using sound source and SEQ playback
-
- Combine programs in development environment (PC/AT)

