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R8C Family, H8/300H Tiny Series, and M16C/Tiny Series

M3S-S2-Tiny: Sound Data Expansion Software for Tiny Microcontrollers

Introduction

This document explains the usage of the sound data expansion software library along with a sample program.

Target device

Tiny microcomputer (R8C/Tiny series, H8/300H Tiny series, and M16C/Tiny series)

Contents

1. Library function

This section explains the specifications of the library functions.

1.1 Initialization (adpcm_init4)

Prototype

```
void adpcm_init4( T_ADPCM *pADPCM );
```

Explanation

This function initializes the sound data to be expanded.

This function has to be executed only once before expanding consecutive ADPCM data.

The T_ADPCM structure datatype is declared in the header file adpcm4.h. Before executing this function, declare the T_ADPCM type structure variable that is to be passed as an argument. Value need not be set to the argument before this function is executed.

Return value

none

1.2 Expansion (adpcm_decode4)

Prototype

```
int adpcm_decode4( T_ADPCM *pADPCM );
```

Explanation

This function converts the encoded 4bit ADPCM data into decoded 16bit PCM data. The ADPCM data currently pointed to by the "input" pointer is decoded and the results are placed in the RAM buffer pointed to by the "output" pointer. The number of 16 bit samples decoded by each call to this function is determined by "size" and must be a multiple of 2.

Define the output sample buffer before calling this function. The size of this buffer depends upon the “size” variable. Required output memory will be size × 16 bit.

E.g. If size = 16, define "signed short buffer[16]" to allocate storage for output sample buffer.

The values to be set for the argument pADPCM are as indicated in Table 1

Table 1 argument pADPCM structure variable

Member	Type	Explanation
input	unsigned char *	Top address of ADPCM data area.
output	signed short *	Top address of PCM data(expanded data) area.
size	unsigned int	Conversion size of ADPCM data (Should be specified in multiples of two).
id	signed char	Unused (Do not set any value, for internal library use.)
vp	signed short	Unused (Do not set any value, for internal library use.)

【 attention 】 This function changes neither the input pointer, nor the output pointer nor the size. The user code must advance the pointers if necessary.

Return value

If the conversion size of the ADPCM data is an odd number, -1 is returned, else 0 is returned.

2. Sample program

This section explains the sample program for ADPCM decoding. The attached sample program is in the form of a HEW（HighPerformance Embedded Workshop) workspace. Change the initialization of the microcomputer and its peripherals according to the user system.

2.1 Outline

When the switch is pressed, sound is played back (Sound is played back using PWM output).

In the main function, the ADPCM data is expanded and put into the PCM buffer as soon as the PCM buffer is emptied by the timer interrupt. This continues until all the ADPCM data is output. The PCM data is fetched from the buffer by the timer interrupt around every 90 microseconds(*).The PCM data is transferred to the PWM output by the ISR. The sampling frequency of the sound data is 11.025kHz.

(*)90 μ sec≒1/11.025kHz)

The size and the storage area of the sound data are defined by the following macros.

Size of sound data (twice ADPCM data size)	:Macro name PCM_DATA_SIZE1
Start address in storage area	:Macro name ADPCM_ADDR1

While this sample software requires polling on a short time basis in the main loop to prevent buffer under-run of the PCM data buffer, this is not practical user system. The user can consider other mechanisms such as buffer expansion in periodic interrupt or via RTOS to meet buffer expansion requirements of the system.

2.2 Flow

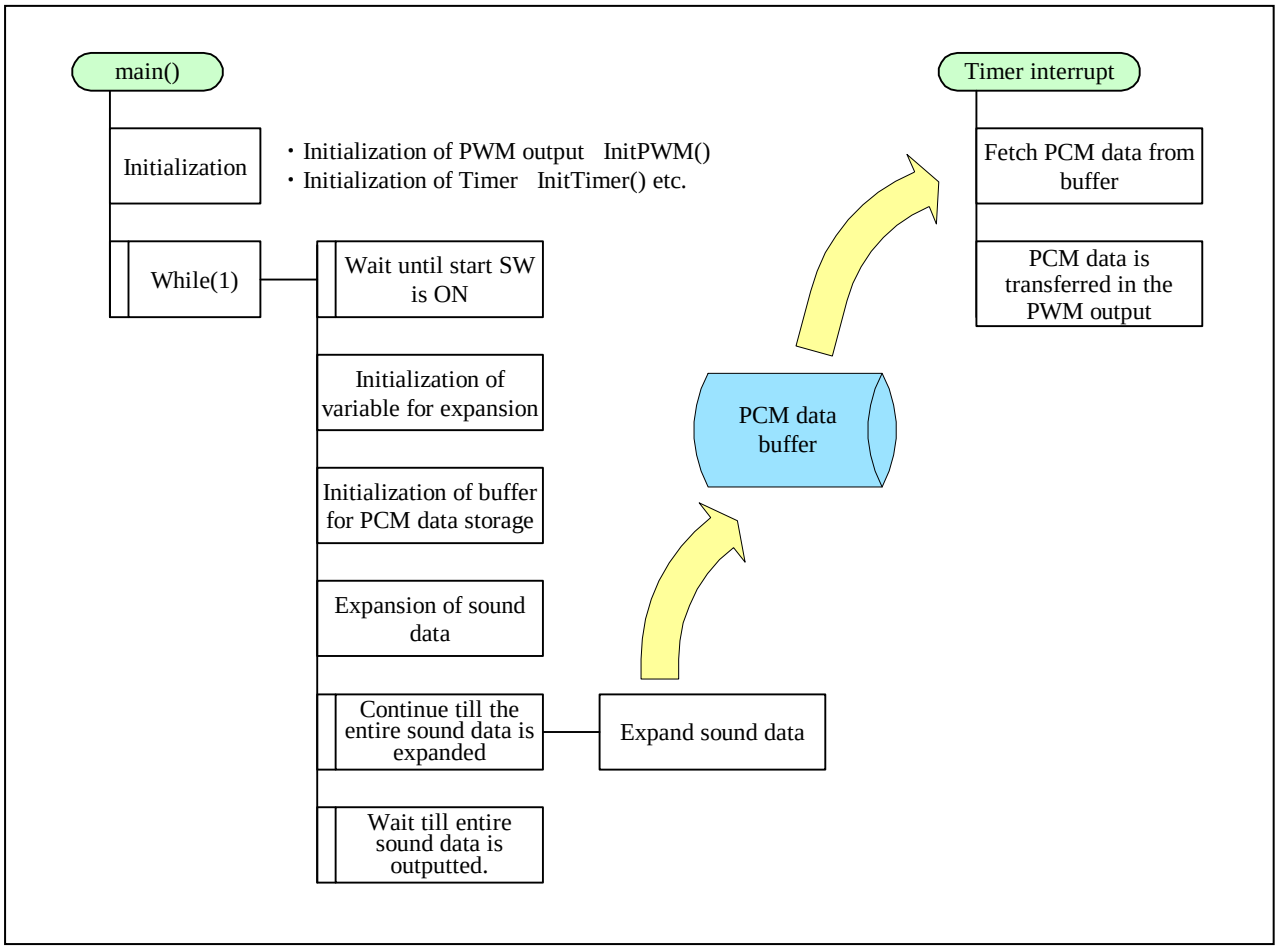

Figure 1 Flow of sample program

2.3 Function list

Table 2 function list

No.	Function name	Outline
1.0	main	ADPCM compressed voice data in ROM area is expanded and the sound is reproduced. The ADPCM sound data is expanded in groups of 4.
1.1	InitCLOCK	The clock of the microcomputer and other clock related registers are initialized.
1.2	InitPWM	The PWM output function is initialized. Operating speed is setup.
1.3	InitTimer	The timer for interrupt processing is set. The interrupt processing starts according to the sampling rate of the sound data.
1.4	InitDecInfo	Decoded information structure(DECINFO) initialization.
1.4.1	adpcm_init4	The sound data for expansion is initialized. - This is a library function.
1.5	InitRingBuffer	Initializes setting of the ring buffer to store decoded data.
1.6	DecodeProc	Converts ADPCM data into PCM data and stores the decoded data in a ring buffer. ADPCM Input pointer is updated here.
1.6.1	adpcm_decode4	4bit ADPCM data is converted into 16bit PCM data. - This is a library function.
1.6.2	RingBufferSetData	Check the state of the ring buffer before writing data.
1.6.2.1	RingBufferPush	Decoded PCM data is pushed to a ring buffer.
1.6.2.1.1	Convert16to8	Convert PCM data(16bits) into PCM data(8bits). Decoded PCM data is scaled to PWM output levels here.
2.0	(*) tra_irq	Output decoded PCM data every cycle of the sampling frequency using PWM.
2.1	SetPCMdataCH0	Send sound data(PCM) to PWM output.

(*) Function name for the sample software for R8C/Tiny.
"INT_TimerB1" in the sample program of H8/Tiny. "tb0_int" in the sample program of M16C/Tiny.

2.4 Function chart

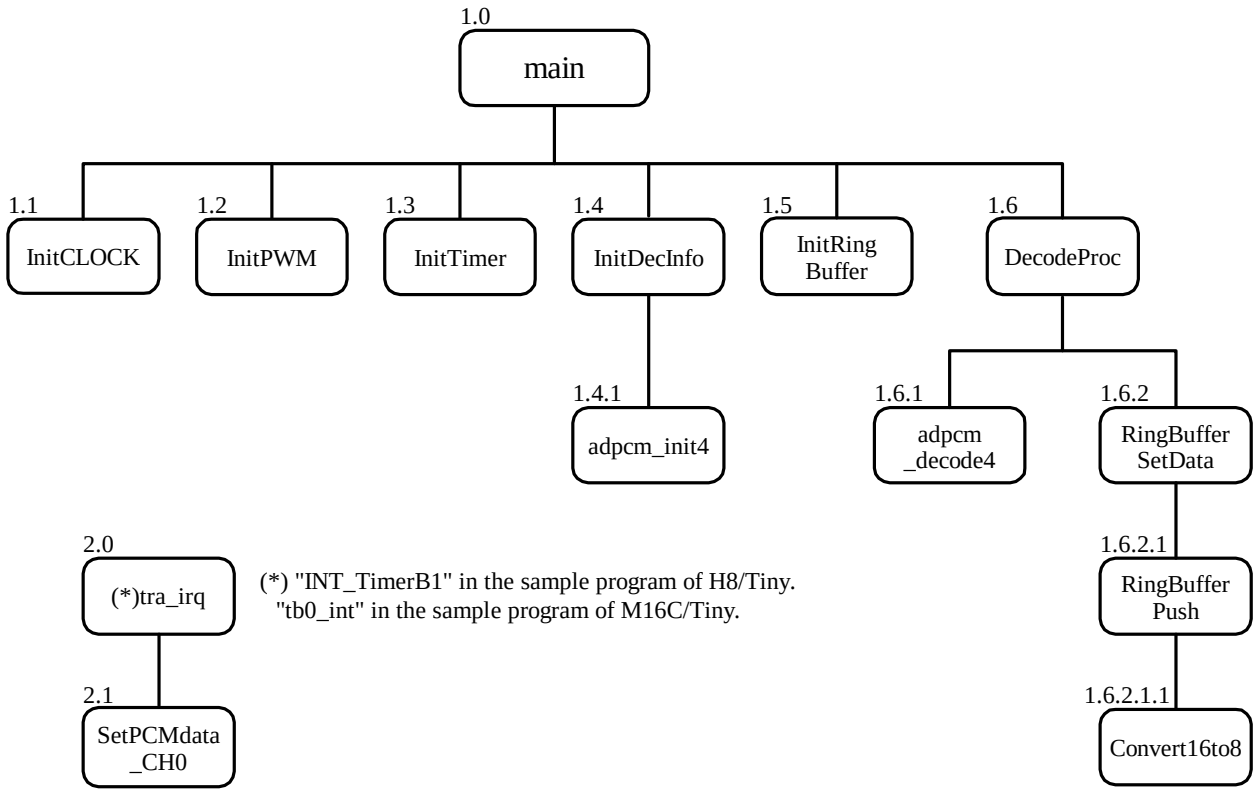

Figure 2 function chart

2.5 Folder composition in workspace

```
S2_sample_***Tiny                   Workspace directory of HEW (*** is microcomputer name)
|
|
|-- Type name of microcomputer      Project directory of HEW
        |
        |-- audiodata               ADPCM sound data (sound_adpcm.dat)
        |
        |-- Debug                   Configuration directory of HEW
        |
        |-- Debug_***_E8_SYSTEM     Configuration directory of HEW (*** is microcomputer name)
        |
        |-- lib                     Sound expansion library storage directory
        |
        |-- Release                 Configuration directory of HEW
        |
        |-- src                     Sample source storage directory.
                                    The header file "Adpcm4.h" is included.
```

3. Sound data modification procedure

This section explains sound data modification procedure for the sample program. The modified sound data is to be given as an input to the sample program.

3.1 Creation of sound data

3.1.1 Preparation of wav file

Prepare sound data with specification as given in Table 3.

Table 3 sound data specification

Quantization bits	16bit
Channel	Mono
Sampling frequency	11.025kHz
File format	WAV

3.1.2 Compression of sound data

Make the ADPCM data (binary form) from the Wave (.wav) file using the bundled "ADPCM_TOOL(ADPCM.exe)". Please refer the manual of the tool “ADPCM_TOOL” for its usage.

3.2 Change in sample program

3.2.1 PCM_DATA_SIZE1

The value of the macro PCM_DATA_SIZE1 should be set in sample.c file of the sample program. It should be set according to the size of the sound data used. A set value has to be at least twice the size of ADPCM data (compression data).

```
[E.g. When size of ADPCM data is 0x1ef1 bytes, setting will be ]
 #define PCM_DATA_SIZE1 0x3de2 /* size of sound data after decode(compressed data) */
```

3.2.2 ADPCM_ADDR1

Set the value of address "ADPCM_ADDR1" in “sample.c” file of the sample program as per the location of ADPCM data.

```
[ If ADPCM data is starts from 0x4000 ]
 #define ADPCM_ADDR1     0x4000     /* top address of ADPCM sound data storage */
```

3.3 Loading of sound data

Download ADPCM data to the address set to "ADPCM_ADDR1". ADPCM data is the data created using the ADPCM_TOOL. Please refer the HEW manual for the downloading procedure.

4. Library characteristic

This section explains the memory occupation and the speed performance (reference values) of the library functions.

4.1 Occupied memory size

Table 4 Occupied memory

Microcomputer	Mode/ Option	ROM	RAM(*)	Stack	
				adpcm_init4()	adpcm_decode4()
R8C/Tiny	-R8C	403	0	3	9
	-R8CE	419	0	3	11
H8/Tiny	Normal	432	0	2	16
	Advanced	454	0	4	22
M16C	-	419	0	3	11

Unit: Byte

(*)The structure variable area (10 bytes or more) for the library function is necessary.

4.2 Expansion processing speed (reference value)

Table 5 expansion processing speed (reference value)

Microcomputer	Mode/ Option	Expansion processing time (µsec) (size=4)
R8C/Tiny	-R8C	46
	-R8CE	49
H8/Tiny	Normal	36
	Advanced	39
M16C	-	33

* The above values are reference values at an operating frequency of 20 MHz for the given microcomputers.

5. 10 bit sound data

The sound data expanded by the adpcm_decode4 function is 16 bit in length. According to the system being used, change the bit length of the sound data. In the sample program, the data of 16 bit length has been converted into 8 bit length using the Convert16to8() function. This chapter explains the function that converts 16 bit sound data into 10 bit sound data (When 10-bits D/A convertor etc. are used, this can be used.).

The data of length 16bit is converted into data of length 10 bit by the following functions.

Argument: 16 bit data before conversion
Return value: 10 bit data after conversion

```
short Convert16to10( short data )
{
    return (short)( ((data + 0x20) >> 6) + 512 );
}
```

6. Data expansion of two or more channels

Using this library, two or more compression data(ADPCM data), can be expanded simultaneously and independently. It is possible to connect the output of two or more channels at the same time.

Define the T_ADPCM data structure separately for each channel when two or more channels are to de decoded. Also the adpcm_init4() function and the adpcm_decode4() functions needs to be executed separately for each channel.

【 example of decoding sound from of two channels 】

```
#Define NUM_CHANNELS   2
/* Definition of structure variable of each channel */
T_ADPCM ch[NUM_CHANNELS]
for (index=0; index < NUM_CHANNELS; index++){
    adpcm_init4( &ch [index] ); /* Initialization for ch data expansion */
}

/* expansion processing */
```

```
Set value of members (input,output,size) of ch0
Set value of members (input,output,size) of ch1
```

```
for (index=0; index < NUM_CHANNELS; index++){
    adpcm_decode4( &ch[index] ); /* Expansion of ch data */
}
Hereafter, the expansion processing is repeated.
```

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Revision Record

		Description	
Rev.	**Date**	**Page**	**Summary**
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