To our customers,

---

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April 1\(^{st}\), 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation ([http://www.renesas.com](http://www.renesas.com))

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H8/300L SLP Series
SLP Tone Generator (ToneGen)

Introduction

Two methods of generating tones using the H8/38024 SLP MCU are:

(1) Pulse width modulation (PWM) implementation
(2) Timer toggle output implementation

Target Device

H8/38024

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1. Overview

Tone generator is a methodology whereby tone signals are defined in a musical sequence to produce a song. Two types of implementation are described here. Both implementations use the same musical tone data and rhythm between two musical tones (rhythm is fixed to reduce the size of musical tone data).

1.1 Musical Tone (Notes)

If a long hollow tube is hit, a fairly constant sound (pitch) is heard due to a shock-wave oscillating along the tube at a certain speed (frequency). A “note” is described a musical frequency, i.e., the pitch of a piano key or guitar string. By convention, notes are named as:-

A, A#, B, C, C#, D, D#, E, F, F#, G, G#

The suffix “#” denotes sharp and “b” denotes flat. Also note that A# = Bb, C# = Db, D# = Eb, F# = Gb and G# = Ab. The names chosen are the de facto standard for nearly all music.

“Octaves” of a note are just multiples of the original frequency. Let’s say that a length of hollow tube has a frequency of 264 Hz and normally call it “C”. If the length is half of the original length, the frequency will be double. This creates another “C” but at one octave higher than the first (264 \times 2 = 528 Hz).

<table>
<thead>
<tr>
<th>Hertz</th>
<th>Octave = 0</th>
<th>Octave = 1</th>
<th>Octave = 2</th>
<th>Octave = 3</th>
<th>Octave = 4</th>
<th>Octave = 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>55.000</td>
<td>110.000</td>
<td>220.000</td>
<td>440.000</td>
<td>880.000</td>
<td>1760.000</td>
</tr>
<tr>
<td>A#</td>
<td>58.270</td>
<td>116.541</td>
<td>233.082</td>
<td>466.164</td>
<td>932.328</td>
<td>1864.655</td>
</tr>
<tr>
<td>B</td>
<td>61.735</td>
<td>123.471</td>
<td>246.942</td>
<td>493.883</td>
<td>987.676</td>
<td>1975.353</td>
</tr>
<tr>
<td>C</td>
<td>65.406</td>
<td>130.813</td>
<td>261.626</td>
<td>523.251</td>
<td>1046.502</td>
<td>2093.005</td>
</tr>
<tr>
<td>C#</td>
<td>69.296</td>
<td>138.591</td>
<td>277.183</td>
<td>554.365</td>
<td>1108.731</td>
<td>2217.461</td>
</tr>
<tr>
<td>D</td>
<td>73.416</td>
<td>146.832</td>
<td>293.655</td>
<td>587.330</td>
<td>1174.659</td>
<td>2349.318</td>
</tr>
<tr>
<td>D#</td>
<td>77.782</td>
<td>155.563</td>
<td>311.127</td>
<td>622.254</td>
<td>1244.508</td>
<td>2489.016</td>
</tr>
<tr>
<td>E</td>
<td>82.407</td>
<td>164.814</td>
<td>329.628</td>
<td>659.255</td>
<td>1318.510</td>
<td>2637.020</td>
</tr>
<tr>
<td>F</td>
<td>87.307</td>
<td>174.614</td>
<td>349.228</td>
<td>698.456</td>
<td>1396.913</td>
<td>2793.826</td>
</tr>
<tr>
<td>F#</td>
<td>92.499</td>
<td>184.997</td>
<td>369.994</td>
<td>739.989</td>
<td>1479.978</td>
<td>2959.955</td>
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<tr>
<td>G</td>
<td>97.999</td>
<td>195.998</td>
<td>391.995</td>
<td>783.991</td>
<td>1567.982</td>
<td>3135.963</td>
</tr>
<tr>
<td>G#</td>
<td>103.826</td>
<td>207.652</td>
<td>415.305</td>
<td>830.609</td>
<td>1661.219</td>
<td>3322.438</td>
</tr>
<tr>
<td>A</td>
<td>110.000</td>
<td>220.000</td>
<td>440.000</td>
<td>880.000</td>
<td>1760.000</td>
<td>3520.000</td>
</tr>
</tbody>
</table>
1.2 PWM Implementation

The built-in 10-bit PWM module can be used to generate the PWM pulse stream with the desired duty cycle. It can also be used as a D/A converter by connecting a low pass filter. There are four clock sources available as an input clock. With 10-bit resolution, we can get four pulse trains in each conversion period. Depending upon the register bit settings, we can get four conversion periods as described above. This module can be placed independently in the standby mode when not in use to conserve the power.

![Diagram of PWM Implementation](image)

**Figure 1** Usage of PWM as D/A Converter

The primary purpose of the 10-bit PWM module is to provide a high resolution D/A converter using an external low pass filter. The basic task of any D/A converter is to take a binary number and convert it to voltage or current with an analog form. Other than a traditional D/A converter, which is difficult to implement under the CMOS fabrication technology for precision, the alternative solution is to make a counter whose output duty cycle can be varied under software control – that is a Pulse Width Modulation.

Using a simple low-pass filter (or a band pass filter if no DC component is desired), the analog output of the filter is basically $V_{out} = V_{cc} \times \text{Duty Cycle}$ (in an ideal case, notice that the output is a function of duty cycle rather than the frequency).

**For example:** $V_{out} = 5.00 \text{ V} \times 50\% \text{ Duty Cycle} = 2.5 \text{ V}$

If the generated DC voltage level is in a sinusoidal manner, a sine wave is generated.

![Diagram of Sine Wave](image)

**Figure 2** Typical Sine Wave Diagram
The sample period is time duration between two PWM values. Normally, timer is used to reload the sine wave value into the PWM module. Therefore AEC (asynchronous event counter) timer is used for this purpose.

For example, the frequency of the crystal used is 9.8304 MHz,

\[ T_{\text{interrupt}} = \left( \frac{1}{\phi} \right) \times 256 \text{ count} \]
\[ = \left( \frac{1}{\left(\frac{\phi_{\text{osc}}}{2}\right)} \right) \times 256 \text{ count} \]
\[ = \left( \frac{1}{\left(\frac{9.8304\text{MHz}}{4}\right)} \right) \times 256 \text{ count} \]
\[ = 104.16 \mu s \]

The sample period is equal to one AEC interrupt occurrence. The Interrupt Service Routine (ISR) will put the calculated pulse width into the PWM width register.

Sample frequency = \( 1 / T_{\text{interrupt}} \)
\[ = 9600\text{Hz} \]

The calculation of the pulse width requires increment counter value. The increment counter value is calculated as follows.

Assumptions:
- 256 sample for the complete sine wave table
- sample frequency = 9600 Hz
- signal frequency = 440 Hz (e.g. note “A” at the third octave)

Increment counter value = \( 256 / \text{number of increments} \)

Number of increments depend on sample frequency and signal frequency and it is equal to how many time the given signal increments through the sine wave table in one complete cycle.

Number of increments = sample frequency / signal frequency
Increment counter value = \( 256 / \left(\frac{\text{sample frequency}}{\text{signal frequency}}\right) \)
\[ = 256 * \frac{\text{signal frequency}}{\text{sample frequency}} \]
\[ = 256 * \left(\frac{440\text{ Hz}}{9600\text{ Hz}}\right) \]
\[ = 11.73 \]

All these calculations are done by the compiler; therefore the user must change the default value in order to use this with other parameters.
1.3 Timer Toggle Output Implementation

There are several methods to implement tone generator by software means. For example, timer F is chosen because it is equipped with toggle output and output compare functions. The initial value of the toggle output can be set. Timer F counter value will increment on each input clock pulse. The timer F counter value is constantly compared with the value set in output compare register F, and the counter can be cleared, an interrupt request, or output toggled, when the two values match. Timer F can also function as two independent 8-bit timers.

Figure 3 Block Diagram of Timer F Output Compare Operation

Figure 3 describes how a PWM is output through TMOFH/TMOFL pin using the timer F output compare function.

- The 5 MHz system clock is input to the prescaler S that divides the clock by 32, 16 and 4.
- TCRF is an 8-bit write-only register, which selects an input clock and sets the output level of the TMOFL pin.
- Timer counters FL and FH (TCFL / TCFH) are 8-bit read/write up-counters. In this example, the input clock is $\phi/32$.
- Timer control/status register F (TCSRF) disables the clearing TCFL by compare match and enables the counter FL overflow interrupts.
- The data of output compare register FL (OCRFL) is always compared with that of TCFL.
- When the values of both registers match, the compare match is generated and TMOFL pin is toggled. At the same time, a compare match flag L (CMFL) is set to 1 and an interrupt is requested to the CPU.
Figure 4  Timer F Output Compare Operation

Figure 4 shows how the timer F compare-match function can be used to generate a pulse with an arbitrary duty cycle i.e., a digital tone signal. The timer counter register FL (TCFL) determines the tone signal clock cycle, or period, of the output waveform, while the value stored in Output compare Register (OCRFL) determines the duty cycle. The calculation of the desired duty cycle can be done as shown in the above formula. It is only necessary to program timer F once. There is no need to reload OCRFL unless you want to change the duty cycle of the output.

The user can generate two digital tones by combining the two timer F toggle outputs (TMOFL and TMOFH), e.g. one for treble (high frequency) and one for bass (low frequency). Figure 5 below shows the block diagram of timer toggle output tone generator.

Figure 5  Block Diagram of Timer Toggle Output Tone Generator
2. Hardware Implementation

2.1 PWM Implementation

The musical tone is generated by the Pulse Width Modulation (PWM) module of the SLP MCU. The software will modulate the sinusoidal signal into a pulse train of fixed periods but changing width. The changing width of the pulses corresponds to the voltage level of the sine wave. With an external low pass filter (LPF) at the PWM output pin, the PWM signal will be demodulated. The LPF acts as an integrator, which transforms the pulse train into analog sinusoidal signal. The musical tone is then sent to the audio amplifier for sound output.

2.1.1 Warm-up Function:

Generally audio signal has an average value at ground level (It will fluctuated between positive and negative regions). However, there is no negative supply in this implementation, thus a DC offset to 1/2 Vcc level is required. This is known as the “warming up” of the audio amplifier. This is required only at the power up stage (to charge up the capacitor), to avoid unnecessary noise output at the early stage.
2.2 Timer Toggle Output Implementation

The digital tone is generated by the timer F toggle output of the SLP MCU. The software will generate signal with different pulse width when the timer F output compare value is reloaded with new value. The two timer F toggle outputs (low counter and high counter) are combined, resulting in the generation of two digital tones simultaneously. The two digital tones are fed to the audio amplifier via the resistor mixer. The user will be able to hear the tones from the loud speaker.

![Schematic Diagram for Timer Toggle Output Tone Generator](image-url)
3. Operation and Observation

The hardware circuitry provides flash-programming capability. User can download tone generator demo program via PC serial port. The PC application software used to download user program is the freeware - Flash Development Toolkit (FDT) that is available from www.eu.renesas.com.

After the program has been successfully downloaded, reset the MCU and execute the program. During the execution, user should be able to listen to the musical tones coming out from the speaker. The demo program will play the same song repeatedly.

The PWM tone generation demo program also can be used with other crystal oscillator value by changing the XTAL value in #define statement.

For example,

- If crystal = 9.8304 MHz  ➔  #define XTAL 9830400L (default)
- If crystal = 4 MHz  ➔  #define XTAL 4000000L

There are two PWM channels in the H8/38024F MCU; user has to define which PWM channel to use before compiling the source code e.g.:

- If PWM1 is used  ➔  #define PWM_use 1 (default)
- If PWM2 is used  ➔  #define PWM_use 2
4. **Program Listing**

The attached code is generated using HEW project generator for the H8/38024F SLP MCU. The free SLP/Tiny toolchain is used.

### 4.1 PWM Implementation

Figure 8 shows the flowchart for the PWM implementation. The source codes for “PWM_tone.c” are listed.

![Flow Chart for PWM_Tone.c](image-url)

**Figure 8** Flow Chart for PWM_Tone.c
/* FILE        :PWM_Tone.c                                          */
/* DATE        :Tue, Sep 09, 2003                                  */
/* DESCRIPTION :Main Program                                    */
/* CPU TYPE    :H8/38024F                                         */
/* This file is generated by Renesas Project Generator (Ver.2.1). */

/*====================================================================*/
/* File Include                                                    */
/*====================================================================*/
#include  <machine.h>
#include  "iodefine.h"
#include  <math.h>
/*====================================================================*/
/* define                                                         */
/*====================================================================*/
#define  XTAL   9830400L
#define  sample_freq (XTAL/4L) / 256L //256 clock cycles per interrupt
#define  C1    ((256L * 523L)/100)/(sample_freq/100)
#define  C1S   ((256L * 554L)/100)/(sample_freq/100)
#define  D1    ((256L * 587L)/100)/(sample_freq/100)
#define  D1S   ((256L * 622L)/100)/(sample_freq/100)
#define  E1    ((256L * 659L)/100)/(sample_freq/100)
#define  F1    ((256L * 698L)/100)/(sample_freq/100)
#define  F1S   ((256L * 740L)/100)/(sample_freq/100)
#define  G1    ((256L * 784L)/100)/(sample_freq/100)
#define  G1S   ((256L * 830L)/100)/(sample_freq/100)
#define  A1    ((256L * 880L)/100)/(sample_freq/100)
#define  A1S   ((256L * 932L)/100)/(sample_freq/100)
#define  B1    ((256L * 987L)/100)/(sample_freq/100)
#define  C2    ((256L * 1046L)/100)/(sample_freq/100)
#define  C2S   ((256L * 1109L)/100)/(sample_freq/100)
#define  D2    ((256L * 1174L)/100)/(sample_freq/100)
#define  D2S   ((256L * 1244L)/100)/(sample_freq/100)
#define  E2    ((256L * 1318L)/100)/(sample_freq/100)
#define  F2    ((256L * 1396L)/100)/(sample_freq/100)
#define  F2S   ((256L * 1480L)/100)/(sample_freq/100)
#define  G2    ((256L * 1568L)/100)/(sample_freq/100)
#define  G2S   ((256L * 1661L)/100)/(sample_freq/100)
#define  A2    ((256L * 1760L)/100)/(sample_freq/100)
#define  A2S   ((256L * 1864L)/100)/(sample_freq/100)
#define  B2    ((256L * 1864L)/100)/(sample_freq/100)
#define  C3    ((256L * 2093L)/100)/(sample_freq/100)
#define  C3S   ((256L * 2217L)/100)/(sample_freq/100)
#define  D3    ((256L * 2349L)/100)/(sample_freq/100)
#define  PWM_use  2  //select "1" for PWM channel 2
              //select "0" for PWM channel 1
/******************************
/*  Function define          */
*******************************/

void init_PWM(unsigned char);
void storeCount(unsigned short);
void aecint(  void );
void init_AEC(  void );
void init_Tone(  void );void off_DTMF(  void );
void init_PWM1(unsigned char selClk1);
void init_PWM2(unsigned char selClk2);
void warm_up(  void );
void play_song(  void );

/******************************
/*Constant Look up Table for Sine Wave value */
*******************************/
const unsigned int  song1[]=
{   
  B2, B2, B2, A2S, G2S, A2S,
  F2S, C2S, C2, F2S, F2, F2S,
  A2S, G2S, B2, B2, A2S, G2S,
  A2S, F2S, A1S, A1S, D2S, D2,
  D2S, F2S, F2, F2, F2, F2S,
  F2, C2S, F2, D2S, B1, C2S,
  D2S, C2S, D2S, F2, F2S, F2,
  F2S, F2S, G2S, A2S, A2S, G2S,
  G2S, G2S, 0xFF
};

const unsigned int  Sine_Table[256]=
{   
  512, 518, 525, 531, 537, 543, 550, 556,
  562, 568, 574, 580, 586, 592, 598, 604,
  610, 616, 621, 627, 633, 638, 644, 649,
  654, 659, 664, 669, 674, 679, 684, 688,
  693, 697, 702, 706, 710, 714, 717, 721,
  725, 728, 731, 734, 737, 740, 743, 746,
  748, 750, 753, 755, 757, 758, 760, 761,
  762, 763, 764, 765, 766, 766, 766, 767,
  767, 767, 766, 766, 766, 765, 764, 763,
  762, 760, 759, 757, 755, 754, 751, 749,
  747, 744, 742, 739, 736, 733, 730, 726,
  723, 719, 715, 712, 708, 704, 699, 695,
  691, 686, 681, 677, 672, 667, 662, 657,
  652, 646, 641, 635, 630, 624, 619, 613,
  607, 601, 595, 589, 583, 577, 571, 565,
  559, 553, 546, 540, 534, 528, 521, 515,
  509, 503, 496, 490, 484, 478, 471, 465,
  459, 453, 447, 441, 435, 429, 423, 417,
  411, 405, 400, 394, 389, 383, 378, 372,
}
unsigned int i=0, j=0, count=0, inc1=0, inc2=0, final=0;
unsigned int lowcnt=0, hicnt=0;
unsigned char Ready = 0, DIGIT = 0;
unsigned int hold=0;

//Main Program

void main ( void )
{
    play_song();
    while (1)
    {
        //Write user program here
    }
}

//Initialize Program

void init_Tone(void)
{
    set_imask_ccr(1);                // Interrupt Disable
    init_AEC();
    #if (PWM_use==1)
        init_PWM1(0); //Select conversion period = 512/(PWM input clock)
    #else
        init_PWM2(0); //Select conversion period = 512/(PWM input clock)
    #endif
}

void init_PWM1(unsigned char selClk1)
{
    if (selClk1 <= 3) // Check if valid, otherwise PWM2 is off
    {
P_IO.PMR9.BIT.PWM1 = 1;  // Configure P91 as PWM2 output pin
P_PWM1.PWCR1.BYTE = selClk1; // Clock select for PWM2, write only
}

void init_PWM2(unsigned char selClk2)
{
    if (selClk2 <= 3)  // Check if valid, otherwise PWM2 is off
    {
        P_IO.PMR9.BIT.PWM2 = 1; // Configure P91 as PWM2 output pin
        P_PWM2.PWCR2.BYTE = selClk2; // Clock select for PWM2, write only
    }
}

void off_DTMF(void)
{
    P_SYSCR.IENR2.BIT.IENEC = 0;
    // AEC Interrupt Request, 1-Enable, 0-Disable
    // compiler directive to select which code to be compile
    #if (PWM_use==1)
        P_IO.PMR9.BIT.PWM1 = 0;   // Turn off PWM1
    #else
        P_IO.PMR9.BIT.PWM2 = 0;   // Turn off PWM2
    #endif
}

/************************************************************/
/*  Initialize Program                                      */
/************************************************************/
void warm_up(void)
{
    set_imask_ccr(0);  // Interrupts, 0-Enable, 1-Disable
    while(count<0x3000) ;
    set_imask_ccr(1);  // Interrupts, 0-Enable, 1-Disable
    Ready = 1;
}

/************************************************************/
/*  play_song Program                                       */
/************************************************************/
void play_song(void)
{
    i=0;

    init_Tone();

    warm_up();
    while(1)
    {
        while (song1[i]!=0xFFFF)
        { i++;
            inc1 = song1[i++];
            set_imask_ccr(0);  // Interrupts, 0-Enable, 1-Disable
            for (j=0; j<0x35000; j++) ;
        }
storeCount(512);
for (j=0; j<10000; j++) ;       // short delay Tone
set_imask_ccr(1);          // Interrupts, 0-Enable, 1-Disable
i = 0;
}

off_DTMF();

/*******************************
/*  Write each digital code into PWDR registers                      */
/*******************************
void storeCount(unsigned short PWDRval_2)
{
    // compiler directive to select which code to be compile
#if (PWM_use==1)
P_PWM1.PWDRL1.BYTE = (unsigned char)(PWDRval_2 & 0x00FF);
    // Write lower 8bits of 10bits data
P_PWM1.PWDRU1.BYTE = (unsigned char) ((PWDRval_2 & 0x0300) >> 8);
    // Write upper 8bits of 10bits data
#else
P_PWM2.PWDRL2.BYTE = (unsigned char)(PWDRval_2 & 0x00FF);
    // Write lower 8bits of 10bits data
P_PWM2.PWDRU2.BYTE = (unsigned char) ((PWDRval_2 & 0x0300) >> 8);
    // Write upper 8bits of 10bits data
#endif
}

/*******************************
/*  AEC Interrupt Service Routine             */
/*******************************
void aecint (void)
{
P_SYSCR.IRR2.BIT.IRREC = 0; // Clear IRREC flag

if(P_AEC.ECCSR.BIT.OVL == 1) // Check for ECL overflow flag
{
P_AEC.ECCSR.BIT.OVL = 0; // Clears flag

if(Ready == 0)
{
    storeCount(count++/128);
}
else
{
    final = (Sine_Table[lowcnt]);
    storeCount(final);
    lowcnt = lowcnt + inc1;
    if(lowcnt>255) lowcnt = lowcnt-255;
    // If reached end of 1 period, then reset
    hicnt = hicnt + inc2;
}
if(hicnt>255) hicnt = hicnt-255;
    // If reached end of 1 period, then reset
}
}

void init_AEC(void)
{
    P_AEC.ECCSR.BYTE = 0x15;
P_AEC.ECCR.BYTE = 0x10;
P_SYSCR.IRR2.BIT.IRREC = 0;  // Clear IRREC flag
    P_SYSCR.IENR2.BIT.IENEC = 1; // AEC Interrupt Request, 1-Enable, 0-Disable
}
The following code listing is the Interrupt service program of “intprg.c”, please insert the below code.

```c
extern void aecint (void); //insert AEC ISR function

__interrupt(vect=12) void INT_Counter(void)
{
    aecint(); //insert AEC ISR function
}
```
4.2 Timer Toggle Output Implementation

Figure 9 shows the flowchart for the timer toggle output implementation. The source codes for “timer_tone.c” are given.

![Flow Chart for timer_tone.c]

Figure 9 Flow Chart for timer_tone.c
/****************************************************************************/
/* File Include */
****************************************************************************/
#include <machine.h>
#include "iodefine.h"

****************************************************************************/
/* define */
****************************************************************************/
#define  XTAL   9830400L
#define  Timer_clk 32L // main clock / 32
#define  C1    (XTAL / (Timer_clk*4L*523L))
#define  C1S   (XTAL / (Timer_clk*4L*554L))
#define  D1    (XTAL / (Timer_clk*4L*587L))
#define  D1S   (XTAL / (Timer_clk*4L*622L))
#define  E1    (XTAL / (Timer_clk*4L*659L))
#define  F1    (XTAL / (Timer_clk*4L*698L))
#define  F1S   (XTAL / (Timer_clk*4L*740L))
#define  G1    (XTAL / (Timer_clk*4L*784L))
#define  G1S   (XTAL / (Timer_clk*4L*830L))
#define  A1    (XTAL / (Timer_clk*4L*880L))
#define  A1S   (XTAL / (Timer_clk*4L*932L))
#define  B1    (XTAL / (Timer_clk*4L*987L))
#define  C2    (XTAL / (Timer_clk*4L*1046L))
#define  C2S   (XTAL / (Timer_clk*4L*1109L))
#define  D2    (XTAL / (Timer_clk*4L*1174L))
#define  D2S   (XTAL / (Timer_clk*4L*1244L))
#define  E2    (XTAL / (Timer_clk*4L*1318L))
#define  F2    (XTAL / (Timer_clk*4L*1396L))
#define  F2S   (XTAL / (Timer_clk*4L*1480L))
#define  G2    (XTAL / (Timer_clk*4L*1568L))
#define  G2S   (XTAL / (Timer_clk*4L*1661L))
#define  A2    (XTAL / (Timer_clk*4L*1760L))
#define  A2S   (XTAL / (Timer_clk*4L*1864L))
#define  B2    (XTAL / (Timer_clk*4L*1975L))
#define  C3    (XTAL / (Timer_clk*4L)/(2093L))
#define  C3S   (XTAL / (Timer_clk*4L)/(2217L))
#define  D3    (XTAL / (Timer_clk*4L)/(2349L))
/**************************************************************/
/*  Function define                                         */
/***************************************************************************/
void init_Tone(void);
void play_song(void);

/******************************************************************************/
/*Constant Look up Table for Sine Wave value                  */
/******************************************************************************/
const unsigned char song1[] =
{
B2,  B2,  B2, A2S, G2S, A2S,
F2S, C2S, C2, F2S, F2, F2S,
A2S, G2S, B2, B2, A2S, G2S,
A2S, F2S, A1S, A1S, D2S, D2,
D2S, F2S, F2, F2, F2, F2S,
F2,  C2S, F2, D2S, B1, C2S,
D2S, C2S, D2S, F2, F2S, F2,
F2S, F2S, G2S, A2S, A2S, G2S,
G2S, G2S, 0xFF
};

/******************************************************************************/
/*Global variable                                                   */
/******************************************************************************/
unsigned int i=0,j=0, count=0;

/******************************************************************************/
/*  Main Program                                                     */
/******************************************************************************/
void main (void)
{
    play_song();
    while (1)
    {
       //Write user program here
    }
}

/******************************************************************************/
/*  Initialize Program                                               */
/******************************************************************************/
//Initialize tone generation function
void init_Tone( void) 
{
    set_imask_ccr(1); // Interrupt Disable

    //Init Timer F start
    // 8 bit timer F counter, Sub clock / 4 selected toggle output enable
    P_IO.PMR3.BYTE = 0x06;
P_TMRF.TCRF.BYTE = 0xCE;
P_TMRF.TCSR.F.BYTE = 0x11;
    //TCF cleared when TCF and OCRF match
}
if (P_TMRF.TCSR.BIT.CMFH == 1) P_TMRF.TCSR.BIT.CMFH = 0;
if (P_TMRF.TCSR.BIT.CMFL == 1) P_TMRF.TCSR.BIT.CMFL = 0;

set_imask_ccr(0);                    // Interrupt Enable

// Init Timer F end

/**********************************************************/
/* play_song Program                                        */
/**********************************************************/
void play_song(void)
{
    unsigned int i=0, j=0;

    init_Tone();
    while(1)
    {
        while (song1[i]!=0xFF)
        {
            P_TMRF.OCR.BYTE.H = song1[i];
            P_TMRF.OCR.BYTE.L = song1[i];
            i++;
            for (j=0; j<35000; j++) ;
        }
        for (j=0; j<35000; j++) ;
        i=0;
    }
    P_TMRF.TCR.BYTE = 0x00;
}
5. References

2. Use PWM as A DAC. (Application Note ref. no: AN0303004, http://sg.renesas.com.)
## Revision Record

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