CMPEN 472, The Pennsylvania State University

Homework 10: Signal Wave Generation and Digital Clock Program with HCS12

Due: Nov. 10, 2023 11:30pm

Objective

To learn interrupt based multi-tasking programming, with multiple interrupt type handling.

Textbook Reading:

1. MC9S12C128 Family Data Sheet: Chapters 9, 13, and 15
2. MC9S12C128 Family Data Sheet: Chapters 8 (for next homework)

Instruction

1. Write a program to generate sawtooth wave, triangle wave, and square wave while the digital clock is running on the background. The wave generation function is based on the Timer Interrupt OC3 at the rate of 125usec (8000Hz). The Homework 10 program generates wave form on the terminal connected to the HC12 by sending the signal value in 8-bit unsigned integer numbers, printed on the terminal screen. One number is printed every 125usec and total 2048 numbers are printed for each wave generation command. At the same time, the digital clock is running and displayed on the 7-segment display connected to the PORTB of the HCS12 board (same as Homework 8).

2. Run and study the following sample program that use Timer OC6 Interrupt:

   Sample Timer OC6 Interrupt program - hw10sample1.asm file.

3. The wave generator and digital clock rules are:

   1. Command gw : generate sawtooth wave, printing 0 through 255, repeated for total 2048 points
   2. Command gw2 : generate sawtooth wave of 100Hz, wave repeated for total 2048 points
   3. Command gt : generate triangle wave, printing 0 through 255, then 255 down to 0, repeated for total 2048 points
   4. Command gq : generate square wave, printing 0 for 255 times, then print 255 for 255 times, then repeated for total 2048 points
   5. Command gq2 : generate square wave of 100Hz, wave repeated for total 2048 points
   6. Print one signal sample (an 8-bit unsigned integer) every 125usec (8000Hz sampling rate)
   7. Capture the terminal output into a file, so the wave can be plotted with Excel or MATLAB. (Click for terminal setup.)
   8. Show '> ' prompt and echo print user keystrokes until the Enter/Return key
   9. In case of an invalid input format, print error message on the next line: 'Invalid input format'
   10. 24 hour digital clock (same as Homework 8), with h, m, and s commands to display hour, minutes, or second
   11. Clock commands ("t", "q", "h", "m", and "s" commands) entered on the terminal screen (same as Homework 8)
   12. Time display: ONLY on the 7-segment displays on PORTB, UPDATE the time display every one second
   13. Use Real Time Interrupt (RTI) feature to keep the time

14. Waveform display: on the terminal screen (ASCII text print, integer number)

4. The Terminal display should look something like the following:

```
>
> gw
     sawtooth wave generation ....

> gw2
     sawtooth wave 100Hz generation ....

> gt
     triangle wave generation ....

> gq
     square wave generation ....

> gq2
     square wave 100Hz generation ....

> ab
     Invalid input format

> gtx
     Invalid input format

> $gw
     Invalid input format

> gw 2
     Invalid input format

>
> t 12:34:56
>
> t 00:00:00
>
> t 23:59:59
>
> t 25:09:30
    Error> Invalid time format. Correct example => 00:00:00 to 23:59:59
>
> t 00:25:75
    Error> Invalid time format. Correct example => 00:00:00 to 23:59:59
>
> t 1:A2
    Error> Invalid time format. Correct example => 00:00:00 to 23:59:59
>
> s 3:33
    Error> Invalid command. ("s" for 'second display' and "q" for 'quit')
>
> m 0
    Error> Invalid command. ("m" for 'minute display' and "q" for 'quit')
>
> q
     Wave Generator and Clock stopped and Typewrite program started.
     You may type below.
```

5. Once your Homework 10 program is finished, run it many times to test that it works. Change the signal wave frequency as well as the wave type as you test your Homework 10 program. Repeat the data acquisition and plotting.

6. Write a report of your Homework 10 program and your experiments. Your report must include:
    1. Cover sheet with homework, course, and your information.
    2. Signal wave plots: wave type variation and frequency variations.
    3. For each signal wave, plot full 2048 points and plot magnified 2 signal cycles (zoom in). Note the signal shape difference among square, triangle, and sawtooth waves. Identify one cycle of signal wave, and verify correct signal frequency by counting how many points are plotted in one wave cycle. (how many 125usec steps)
    4. Run FFT on the 2048-point signal wave data (each of sawtooth [W], triangle [T], and square [Q] signal at different frequency), and plot the FFT results. You will need to add X axis label, the time of each sample point. You may use MATLAB or SciLab FFT command. You should expect frequency peaks for W, T, and Q signals. Use proper horizontal and vertical axis, and label them on your plots.
    5. Write the detailed explanation of each plot, and each experiments/operations.
7. Create your report file. (You can capture any window on the screen by pressing 'Alt' and 'Print Screen' keys together. Once captured, you can paste the window picture into the .doc file by pressing 'Ctrl' and 'v' keys together.)
8. You will be submitting both the report file and program source file for this homework.
9. Make your program user friendly by giving simple directions as to how to correctly use your program.
10. Also, make your program 'fool-proof', never crash or stop based on wrong user response.
11. You may add other features or decorations.
12. Use as many re-usable subroutines as possible, and make your overall program to be small. So you may re-visit your previous Homework, and identify the tasks in your main program that can be made to be subroutines. Once you made those subroutines, your main program becomes much simpler and your overall program be smaller. In many cases, your program may be run faster too.
13. Design the program to start at $3100 and data to start at $3000.
14. Be sure to put much comments so that grader and others can clearly and quickly understand your program. Comments are very important in assembly language programs.
15. You may want to see and check the Sample Grading Sheet for this homework.
16. Copy your 'main.asm' **program** file to 'cmpen472hw10_YourLastName.asm'. For example, mine will be 'cmpen472hw10_choi.asm'.
    Do not ZIP your 'cmpen472hw10_YourLastName.asm' file.
17. Name your Homework 10 **report** file to 'cmpen472hw10_YourLastName_RPT.doc'. For example, mine will be 'cmpen472hw10_choi_RPT.doc'.
    Do not ZIP your 'cmpen472hw10_YourLastName_RPT.doc' file.
18. Turn-in your Homework 10 program file and report file through Penn State CANVAS. Upload your files into the CANVAS Assignment's Homework submission. Be sure to select CMPEN 472 class and correct Homework number, and with correct file names.

Congratulations on your tenth CMPEN 472 homework completion!