

EE 308 – LAB 1**MC9S12 ASSEMBLER AND MONITOR****Introduction and Objectives**

This laboratory introduces you to the following MC9S12 assembly language programming tools:

- The Freescale MC9S12 assembler `as12`. This runs on the PC.
- The D-Bug12 monitor that runs on the MC9S12.

An assembler takes assembly language code in a form that a human can reasonably read (with a little practice), translates it to machine code which a microprocessor can understand, and stores the machine code in a `.s19` file which the MC9S12 monitor program can understand. In this lab we will use the **Freescale `as12` assembler**, which is on the PCs in the Digital/Microcontrollers lab. The `as12` assembler is also included on the CD-ROM which comes with your MiniDRAGON+ board.

The `as12` assembler produces an output file with an `.s19` extension which can be loaded into and run on the MC9S12. The D-Bug12 monitor, running from 9S12 EPROM, loads S19 records into the 9S12 and provides some tools for debugging loaded programs.

Pre-Lab

You should read this entire lab and answer all of the questions in the pre-lab section before coming to lab. The pre-lab questions are repeated on a separate page to help you prepare for lab.

The D-Bug12 monitor allows you to interact with the 9S12 microcontroller. You can use it to load programs, to find out what is in the 9S12's registers and memory, to change the contents of the registers and memory, and many other things. The D-Bug12 commands of interest for this lab are:

ASM, BF, BR, NOBR, G, HELP, LOAD, MD, MDW, MM, MMW, RM, RD, and T.

Read the descriptions of these commands in Chapter 5 of the D-Bug12 Reference Guide.

Questions to answer before lab:

- What is the difference between the MM and MMW commands?
- How would you change the value of the X accumulator to 0x55AA? (There are several ways to do this; you only need to find one way.)

Assembly language is used to write programs for the 9S12. An assembly language instruction will be converted by the assembler into a single machine instruction for the 9S12. The assembly language commands of interest to us for this lab are:

LDAA, STAA, TAB, ABA, and ASRA

Read the descriptions of these commands in the **MC9S12 CPU12 Core Users Guide**. At this point you will not understand everything the guide says about these instructions, but you should understand enough to get you through this lab.

Figure 1 is a simple program for the 9S12. We will use it to illustrate how to use the assembler, the simulator and D-Bug12. Note: We will always use the **SWI** instruction to end a program. This instruction will transfer control the the 9S12 from the program to the D-Bug12 monitor.

```
; MC9S12 demo program
; Hector Erives
; 1/18/08

; This is a program to add the numbers in memory
; locations $2000 through $2003, divide the sum by
; four, and store the result in memory location $2004

prog:   equ   $1000      ; Start program at beginning of RAM
data:   equ   $2000      ; Memory area for data

        org   prog       ; set program counter to 0x1000
        ldaa  input      ; Get first input value into ACC A
        adda  input+1    ; add next value
        adda  input+2    ; add next value
        adda  input+3    ; add next value
        lsra          ; divide by 2
        lsra          ; divide by 2 again
        staa  average    ; Save the average
        swi           ; End program (return to D-Bug 12 monitor)

        org   data
input:  dc.b  $15,$63,$24,$3F ; Input values
average:ds.b 1             ; reserve one byte for average
```

Figure 1: An assembly language program used to get started with as12 and D-Bug12.

Question to answer before lab: What are the contents of the A register after each instruction of the program shown in Figure 1 executes?

We will use D-Bug12 to explore the memory of the 9S12 on your evaluation board. The memory map for your MC9S12 is shown on page 24 of the **MC9S12DP256B Device Users Guide**. (Look the figure labeled “Normal Single Chip”.) Much of the memory is used by the D-Bug12 monitor. For this class you can use **RAM** from **0x1000** to **0x2FFF**, and **EEPROM** from **0x0400** to **0x0FFF**.

The **getting started.pdf** file which comes on the CD with your MiniDRAGON+ board shows how to install and use the AsmIDE software on you personal computer. Use of AsmIDE is also discussed in Section 3.6 of Huang. Use the AsmIDE or a text editor to enter the program shown in Figure 1 before coming to lab and save it under the name **lab01.asm**.

To assemble the program double-click on the AsmIDE icon on your desktop. Open you file with the File:Open menu option. Assemble with the Build:Assemble menu option.

The as12 assembler will create a file called **lab01.lst** which shows what op codes were generated by the assembler, and a file called **lab01.s19**, which is the file you will use with the 9S12 evaluation board.

The Lab

Create a directory for this course (say, U:\EE308). Inside this directory create a subdirectory for this lab (say, D:\EE308\LAB01). Change to this subdirectory, type in the **lab01.s** program, and assemble it with the commands shown above.

Some questions on the output of the assembler:

- Look at the **lab01.lst** file. Where in memory will the machine code for the instruction `staa average` be stored?
- What machine code is generated for the `staa average` mnemonic? Is this what you expected? (Look up the STAA instruction in your **MC9S12 CPU12 Core Users Guide** to determine what code this instruction should generate.)
- At what address will `average` be located in the 9S12 memory?

Connect your MiniDRAGON+ board to your computer using the included serial cable. Make sure AsmIDE is running, and that the Terminal window is active. Power up the MiniDRAGON+ board.

- Use the **MM** command to put 0x55 into memory location 0x2000 and 0xAA into memory location 0x2001. Use the **MD** command to verify that this was done.
- Use the **MMW** command to put 0x55 into memory location 0x2100 and 0xAA into memory location 0x2101. Use the **MD** command to verify that this was done.
- Use the **BF** command to load 0x55 into memory locations 0x2800 to 0x2FFF. Use the **MD** command to verify that it worked.
- Use the **ASM 1000** command to enter the following simple program at address 0x1000. (What does this program do?)

```
clra
clrb
inca
incb
aba
swi
```
- Use the **RM** command to change the value of the Program Counter to 0x1000, the address of the first instruction of the simple program.
- Use the Trace **T** to trace (single step through) the first four instruction of the simple program. Verify that the values in A and B are what you expect.
- Use the **G 1000** command to run your entire program.

Load your program into the EVB. To do this, type **LOAD** into the terminal window, then use the Build:Download menu option to send the program to the EVB.

In the Terminal window type **ASM 1000** followed by the ENTER key. You should see the first instruction of your program, along with its address and machine code. Each time you hit ENTER you should see the next instruction in the program. To exit this mode, type a period before hitting ENTER.

You can trace (execute your program one step at a time) through your program by setting the PC (Program Counter) to the address of the first instruction of your program, and then use the **T** (Trace) command. Trace through your program and observe what is happening to the register and memory. (Use the **MD** command to display memory.)

How do the contents of the A register compare to what you predicted in the Pre-lab after the execution of each instruction?

When you are done tracing through your program, reload it and run the entire program by giving the command: G 1000. Verify that the program worked correctly.

Change the two **lsra** instructions to **asra** instructions. Rerun your program. Does it give a different result? Why?