CMPE-250 Assembly and Embedded Programming

Laboratory Exercise Two

Basic Arithmetic Operations

By submitting this report, I attest that its contents are wholly my individual writing about this exercise and that they reflect the submitted code. I further acknowledge that permitted collaboration for this exercise consists only of discussions of concepts with course staff and fellow students. Other than code provided by the instructor for this exercise, all code was developed by me.

Shubhang Mehrotra
Performed 4th February 2021.
Submitted 11th February 2021.

Lab Section 1
Instructor: Muhammad Shaaban
TA: Anthony Bacchetta
Sam Myers
Payton Burak

Lecture Section 1
Lecture Instructor: Dr. Roy Melton

Abstract

The purpose of this exercise was to explore basic Arithmetic operations in an ARM Cortex-M0+ assembly language program using the Keil MDK-ARM IDE. The activity explores the movement and manipulation of data in the registers to perform the basic Cortex-M0+ arithmetic instructions.

Procedure

To perform arithmetic operations in Assembly Language all operands must be stored in Registers. This allows the system to have quick access to data whenever required by an instruction. This activity aims to solve equation 1:

$$(45 + 6 + ([-13] \div 4) - (7\times 3) - 65 + 33) \qquad \ldots(1)$$

To solve equation 1, the operations required are: addition, subtraction, integer division, and multiplication. While Bits can be added and subtracted directly in assembly using their respective mnemonics, multiplication and integer division are not calculated directly. Multiplication is achieved by a Logical Left Shift operation, while integer division for a Signed number is only obtained by an Arithmetic Right Shift operation, and unsigned bit can be divided using a Logical Right Shift as well.

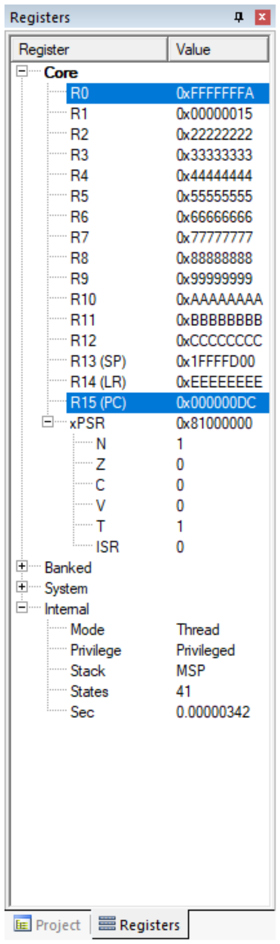
The code written to perform the activity solved the given equation from left to right order, while keeping the order of operations consistent. To initiate, value "45" was moved to a register using the "MOVS" function. The rest of the operations were then carried out by adding the required immediate value to the next register and then adding or subtracting its value to the first register. For instance, the first operation– (*45+6)* was carried out by using the "ADDS" function with an immediate value of *6*.

For multiplication and division, the value of the Shift Amounts for each shift was stored in memory using an EQUate statement. This was done as a good practice to ensure easy accessibility for reuse. Then using the Label for the division statement with an "ASRS" function, integer division was performed on *-13,* and stored in a separate register. The value of this register was then added to the original register. Similarly, multiplication of *7 by 3* was obtained, by first using the Label for multiplication statement with an "LSLS" function, and then adding another *7* to the value, finally adding it to the original register.

The process was continued, obtaining individual results in separate registers, and adding them to the original register to obtain the final answer.

Results

The Code written in the activity was executed and Debugged using the Build Tool and the Debugger Tool. Figure 1 shows the result of the final run. Register R0 shows the value 0xFFFFFFFA, which corresponds to -6 in decimal.



Register	Value
Core	
R0	0xFFFFFFFA
R1	0x00000015
R2	0x22222222
R3	0x33333333
R4	0x44444444
R5	0x55555555
R6	0x66666666
R7	0x77777777
R8	0x88888888
R9	0x99999999
R10	0xAAAAAAAA
R11	0xBBBBBBBB
R12	0xCCCCCCCC
R13 (SP)	0x1FFFFD00
R14 (LR)	0xEEEEEEEE
R15 (PC)	0x000000DC
xPSR	0x81000000
N	1
Z	0
C	0
V	0
T	1
ISR	0
Banked	
System	
Internal	
Mode	Thread
Privilege	Privileged
Stack	MSP
States	41
Sec	0.00000342

Figure 1. Result

All the lines were executed as expected and the result obtained was in line with the calculations:

⇨ $(45 + 6 + ([-13] \div 4) - (7\times 3) - 65 + 33)$
⇨ $(51 + ([-13] \div 4) - (7\times 3) - 65 + 33)$
⇨ $(51 + (-4) - (7\times 3) - 65 + 33)$
⇨ $(47 - (7\times 3) - 65 + 33)$
⇨ $(47 - 21 - 65 + 33)$
⇨ $(26 - 65 + 33)$
⇨ $(-39 + 33)$
⇨ -6

Conclusion

The activity was successful in performing basic arithmetic operations using Assembly Language. The activity also demonstrated good use of Registers and Memory usage in Assembly language to store and retrieve data. Storing data in registers allows quick and repetitive access to the data while ensuring legal bit width is maintained in the process. Memory usage to store frequently used data helps not only reduce instructions, but also the labels help to increase the overall understandability of the code. Overall, the practice successfully helped in increasing the understanding of how mathematical operations are carried out by an ARM Cortex-M0+ microprocessor.