Lab 4

ALU Operations

Objectives

After completing this lab

- Students will learn about various flags and their purposes.
- Students will learn various arithmetic and logic operations.
- Students will be able to perform arithmetic operations and logic operations on n-bit numbers.
- Students will learn what instructions affect which flags.

Flag Register

The 8086 processor contains a 16-bit flag register where nine bits are used as flags as shown in the following figure. Out of which, 6 flags indicate the status of recently executed instruction, while the remaining 3 are control flags.

Flag registers of 8086 microprocessor

Status Flag Registers:

1. Overflow Flag (OF):

Overflow Flag is set to **1** when there is a **signed overflow**. For example, when you add bytes **100 + 50** (result is not in range -128…127).

2. Sign Flag (SF):

Sign Flag is set to **1** when result is **negative**. When result is **positive** it is set to **0**. This flag takes the value of the most significant bit.

3. Zero Flag (ZF):

Zero Flag (ZF) is set to **1** when result is **zero**. For non-zero result this flag is set to **0**.

4. Auxiliary Flag (AF):

Auxiliary Flag is set to **1** when there is an **unsigned overflow** for low nibble (4 bits).

5. Parity Flag (PF):

Parity Flag is set to **1** when there is even number of ones in result, and to **0** when there is odd number of ones.

6. Carry Flag (CF);

Carry Flag is set to **1** when there is an **unsigned overflow**. For example, when you add bytes **255 + 1** (result is not in range 0…255). When there is no overflow, this flag is set to **0**.

Control Flag Registers:

1. Direction Flag (DF):

Direction Flag is used by some instructions to process data chains, when this flag is set to **0** – the processing is done forward, when this flag is set to **1** the processing is done backward.

2. Interrupt Enable Flag (IF):

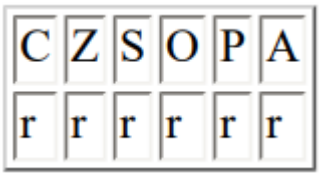
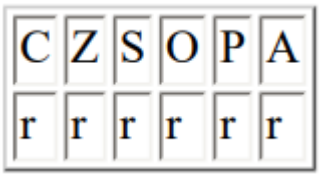
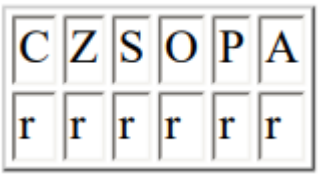
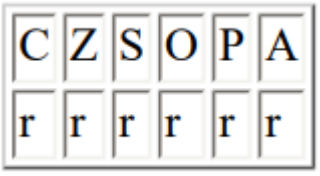
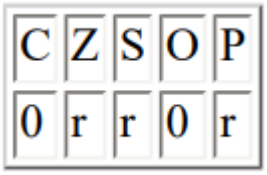
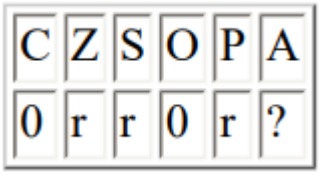
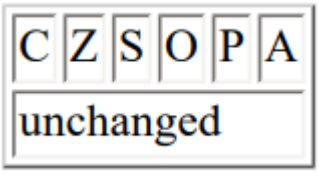
When Interrupt Enable Flag is set to **1** CPU reacts to interrupts from external devices.

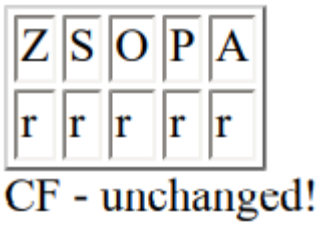
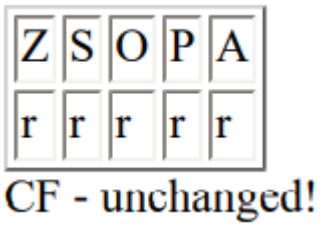
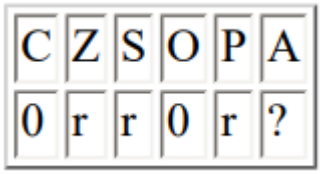
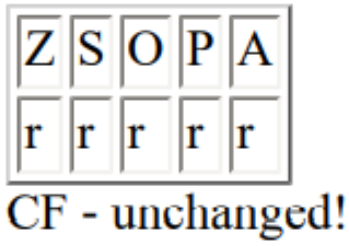
3. Trap Flag (TF):

Trap Flag is used for on-chip debugging.

Arithmetic and Logic Operations

The following table lists various arithmetic and logical operations, their descriptions, and their effects on flags.

Instructions **D – Destination operand** **S – Source operand**	**Description**	**Flag status:** **0 – Clear** **1 – Set** **? – Unknown** **r – depends on result**
ADD D,S	D ←D +S	
ADC D,S	D ←D + S + CF	
SUB D,S	D ← D – S	
SBB D,S	D ← D – S – CF	
AND D,S	D ← D AND S	
OR D,S	D ← D OR S	
NOT D	D ← NOT D	

INC D	D ← D + 1	
DEC D	D ← D - 1	
XOR D,S	D ← D XOR 1	
NEG D	D ← (NOT D) + 1	

Program to add 100 and 50 to check status of various flags.

```
.model small

.data

.code

mov al, 100
add  al, 50

.exit
```

The description of the above program in shown in the following table.

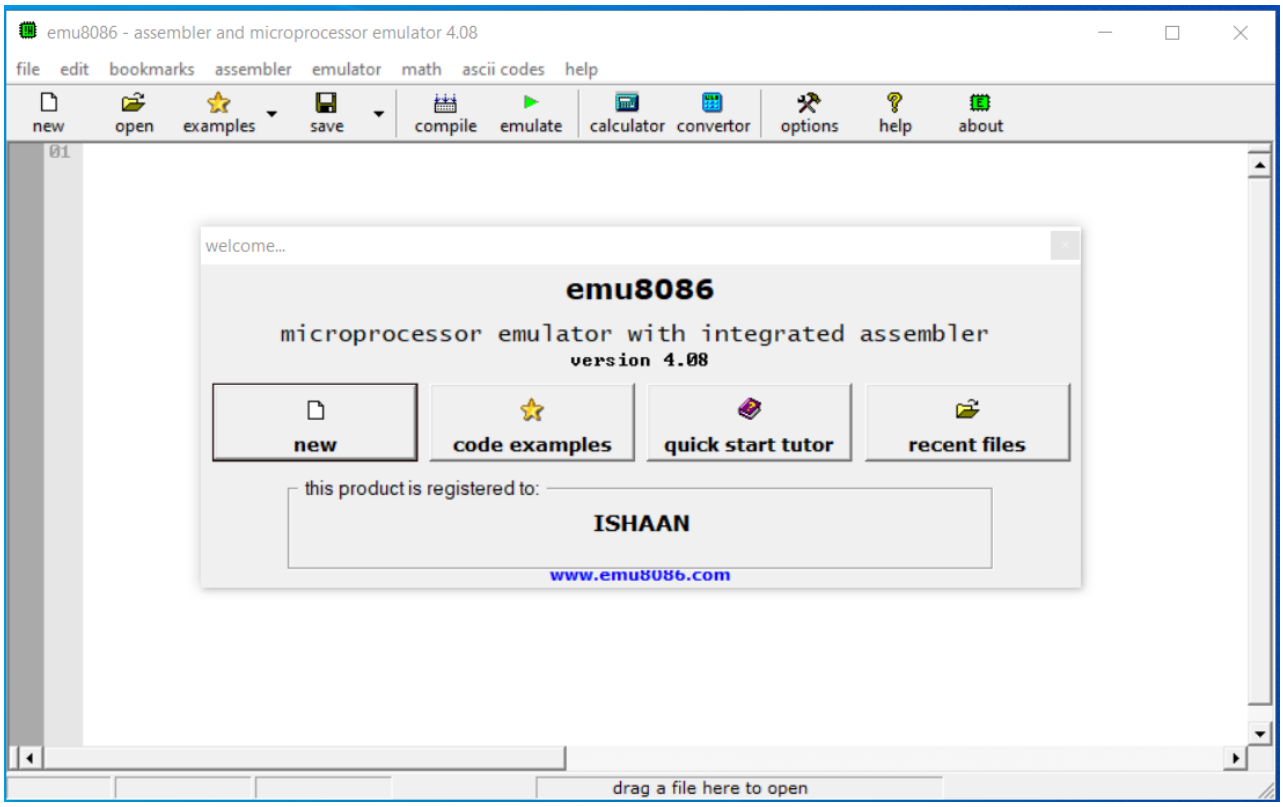
Instruction	Description
mov al,100	Moving value:100 to AL register
add al, 50	Adding value: 50 to the contents of the AL register and storing the result back to the AL register The sum of 150 exceeds the range of 8-bit signed numbers and will set the overflow (OF) flag. The sum of 150 will not affect the carry flag (CF) as the range for 8-bit unsigned numbers is 0–255. The number of ones in 150 is even, which will set the parity flag (PF). The sign flag (SF) will also be set as the most significant bit of the result is 1.

Emu8086 Tutorial Step by Step

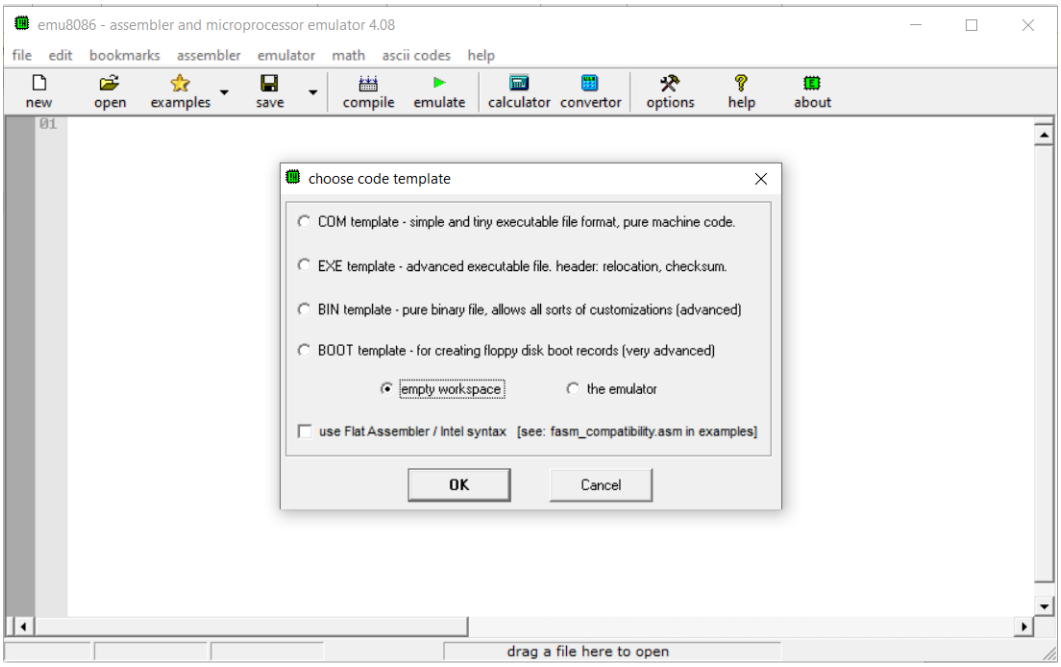
Step-1

Double click on the icon on the desktop 

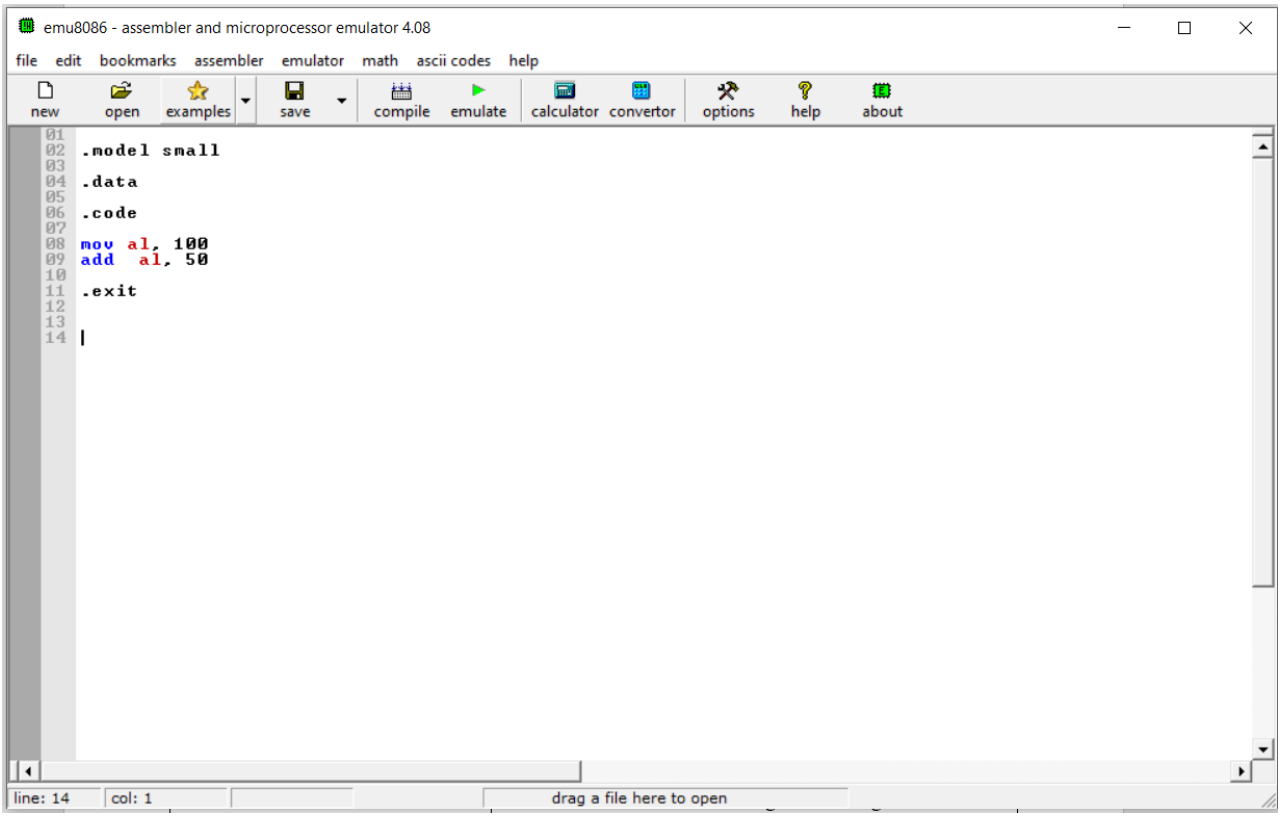
Step-2
The following window will appear. Click on new.



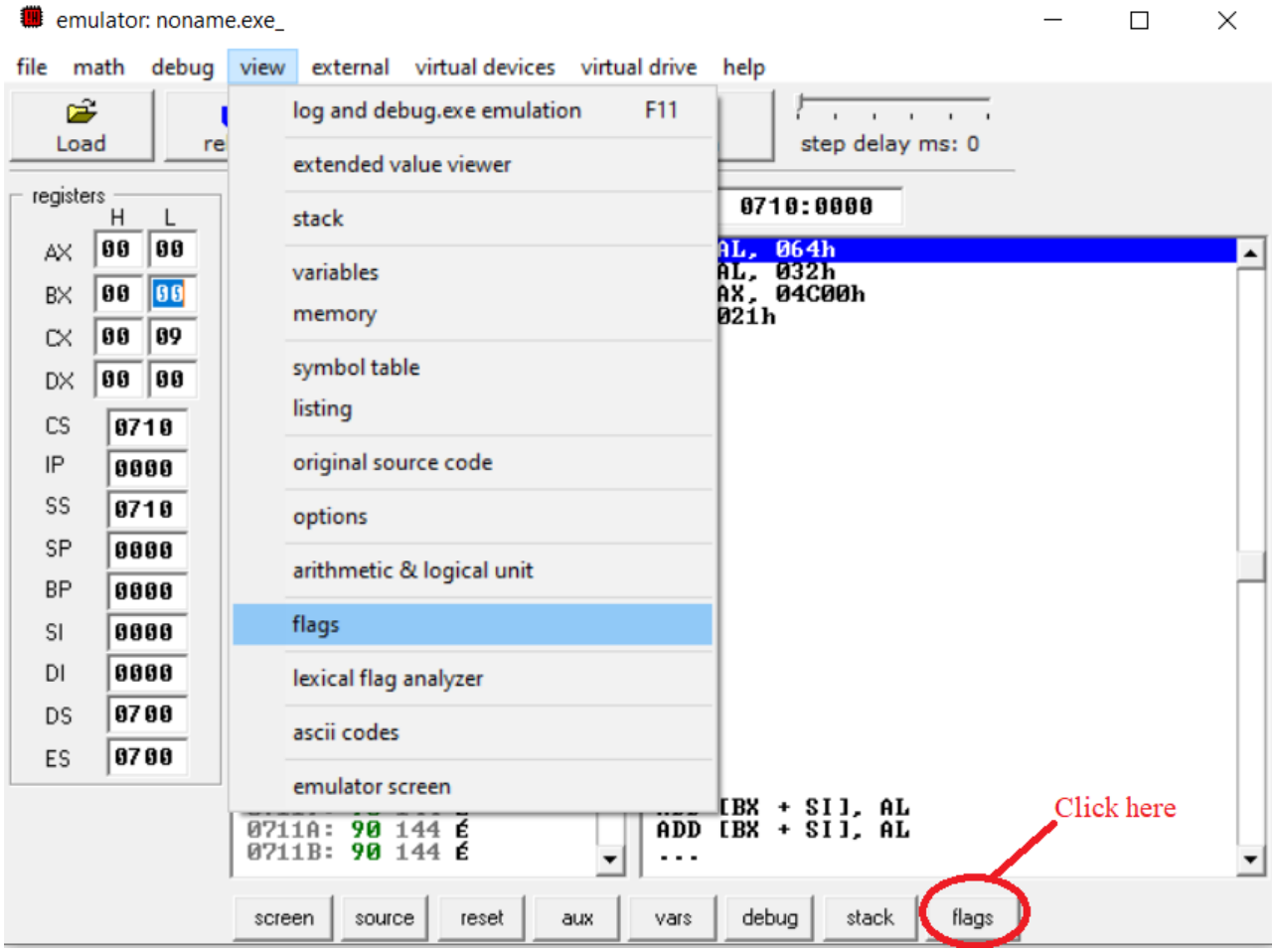
Step-3 Click on empty workspace and press OK.



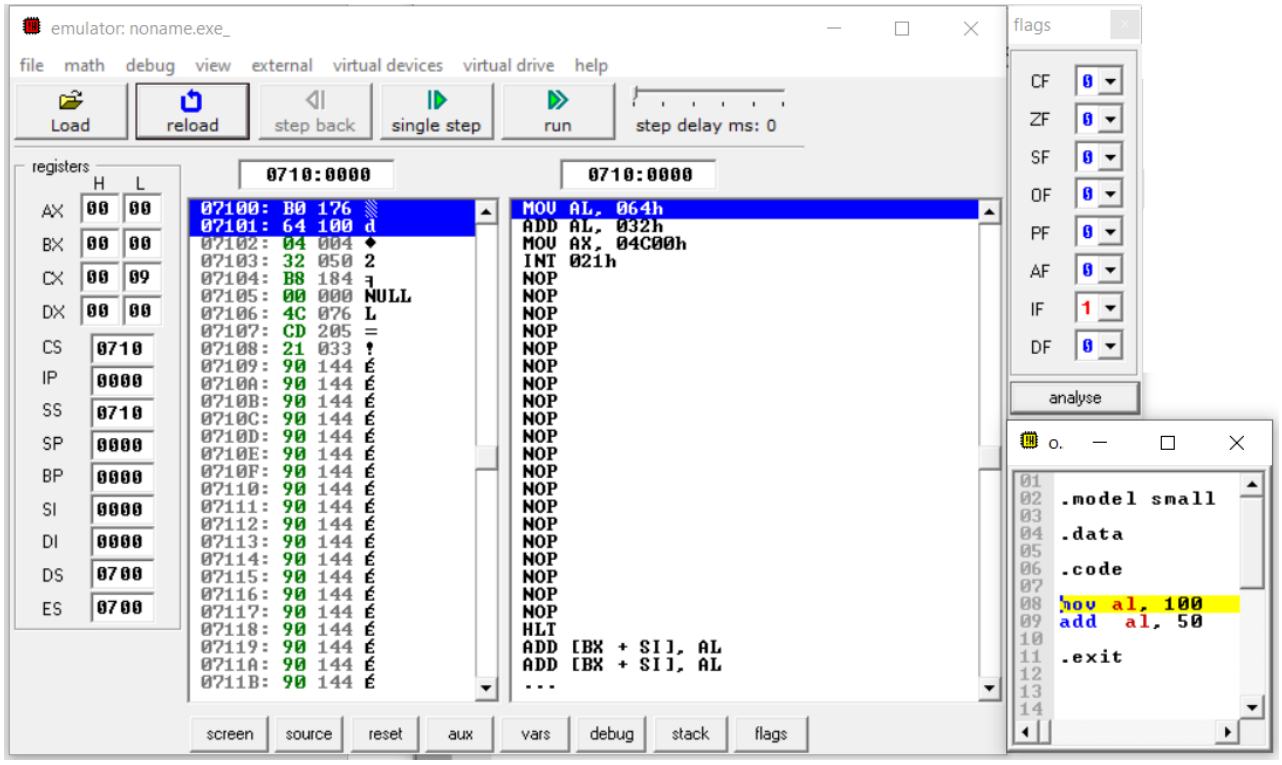
Step-4 Type the code given above and click on emulate.



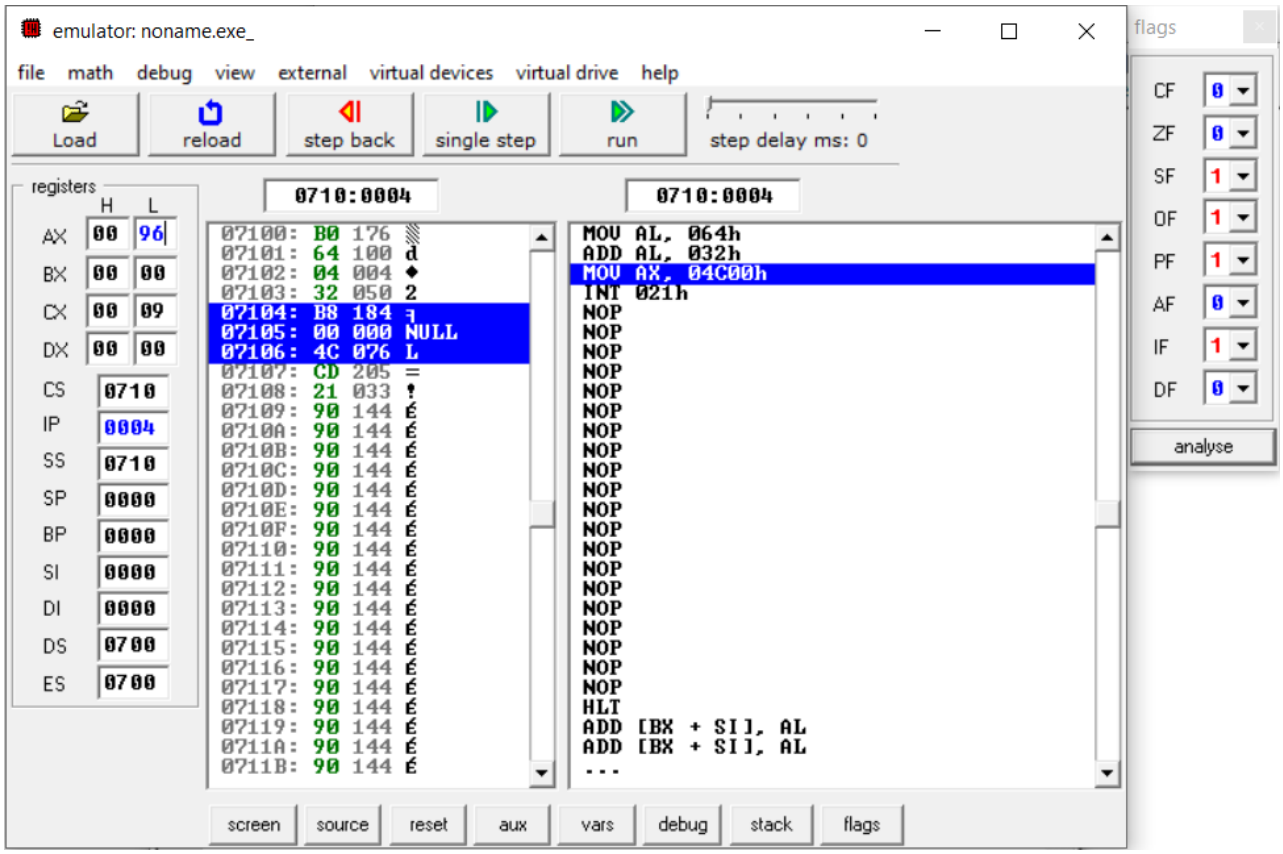
Step-5 Click on "flags" from the view menu OR click on button "flags" at the bottom.



Step-6 Keep clicking on "Single step" to execute program instructions one by one. Stop clicking "Single step" just after the "Add al, 50" instruction to observe various flags.



Step-7 The add al , 50 instruction sets the SF, OF and PF.



Observation:

- Why are the ZF and AF zero?

Practice Exercise

Task-1

Write a program that stores the given two 64-bit numbers into the current data segment at offset: 0x1000 and 0x1008, respectively. The program then calculates the sum of these numbers and stores it at the offset: 0x1010.

Numbers: 0x1F540398, 0xC0A1F02E

Task-2

Write a program to implement the following equation.

X = ~0xFF12 ^ {0xABFF & (0x2113 | 0x2340)}

~	Invert all bits
^	Bitwise XOR
&	Bitwise AND
|	Bitwise OR

Task-3

Perform any ALU operation that sets CF and OF at the same time.