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CPE301 – SPRING 2018

Since it has 16 bit to store the sum you need to get the 16 bit value. Design Assignment 01

DO NOT REMOVE THIS PAGE DURING SUBMISSION:

The student understands that all required components should be submitted in complete for grading of this assignment.

NO	SUBMISSION ITEM	COMPLETED (Y/N)	MARKS (/MAX)
1	COMPONENTS LIST AND CONNECTION BLOCK DIAGRAM w/ PINS		
2.	INITIAL CODE OF TASK 1/A		
3.	INCREMENTAL / DIFFERENTIAL CODE OF TASK 2/B		
3.	INCREMENTAL / DIFFERENTIAL CODE OF TASK 3/C		
3.	INCREMENTAL / DIFFERENTIAL CODE OF TASK 4/D		
3.	INCREMENTAL / DIFFERENTIAL CODE OF TASK 5/E		
4.	SCHEMATICS		
5.	SCREENSHOTS OF EACH TASK OUTPUT		
5.	SCREENSHOT OF EACH DEMO		
6.	VIDEO LINKS OF EACH DEMO		
7.	GOOGLECODE LINK OF THE DA		

Task 1/A: Store 300 numbers starting from the STARTADDS=0x0222 location. Populate the value of the memory location by adding high(STARTADDS) and low(STARTADDS) . Use the X/Y/Z registers as pointers to fill up 300 numbers.

a) Declaring X/Y/Z registers as pointers

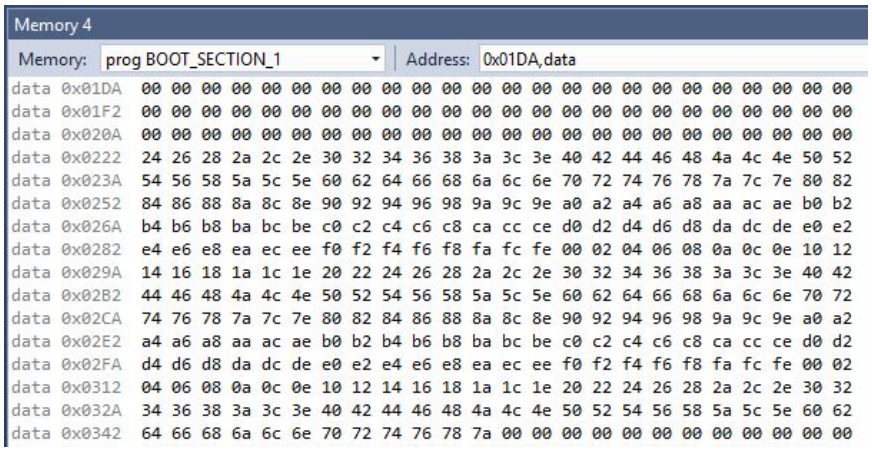
```
start:
; Declare POINTERS
    LDI XL, LOW(0x0222)
    LDI XH, HIGH(0x0222)
    LDI YL, LOW(0x0400)
    LDI YH, HIGH(0x0400)
    LDI ZL, LOW(0x0600)
    LDI ZH, HIGH(0x0600)
```

b) Populating 300 numbers and storing them (counter checks for exactly 300 numbers)

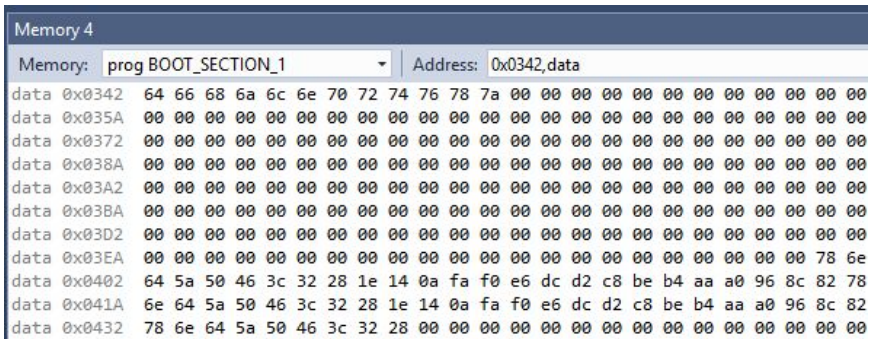
```
    CLR R22                 ; R22 = 0
    LDI R22, LOW(0x0222)    ; R22 = 0x22
    ADD R25, R22            ; R25 = R25 + R22
    LDI R22, HIGH(0x0222)   ; R22 = 0x02

; Populate and store 300 numbers
popLOOP:
    ADD R25, R22            ; R25 += R22
    ST X+, R25              ; Store number
    INC R21                 ; increment counter (low)
    JMP check300first

; Increment higher bits
changeHighfirst:
    INC R20                 ; increment higher bit
    CLR R21                 ; restarts lower bits
    JMP popLOOP

; Checks if counter == 300
check300first:
    CPI R21, 0x00           ; Check to increment high bit
    BREQ changeHighfirst
    CP R24, R21             ; Compare LOW(300) and R21
    BRNE popLOOP
    CP R23, R20             ; Compare HIGH(300) and R20
    BRNE popLOOP
```

c) Memory spaces

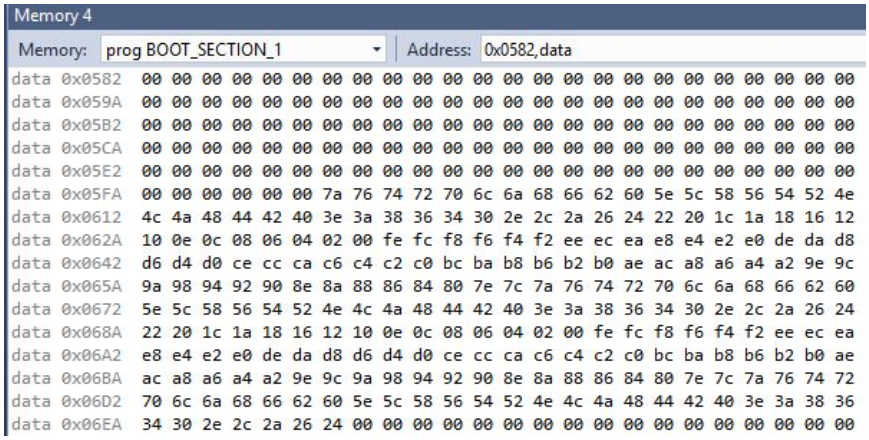
Memory space 0x222, first number placed is 0x24 (36) and last number is 0x7a (122)



Memory space 0x400, numbers divisible by 5



Memory space 0x600, numbers not divisible by 5



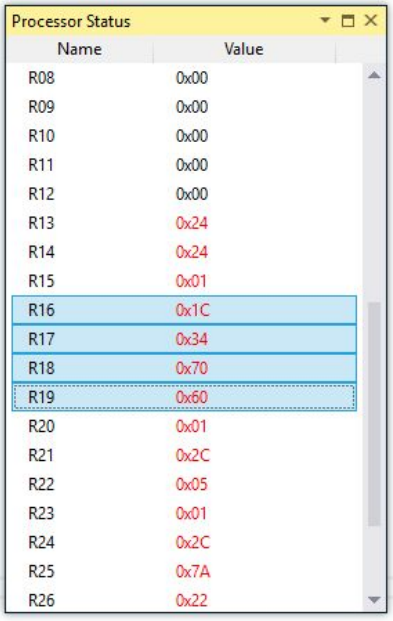
Task 2/B: Use X/Y/Z register addressing to parse through the 300 numbers, if the number is divisible by 5 store the number starting from memory location 0x0400, else store at location starting at 0x0600.
Task 3/C: Use X/Y/Z register addressing to simultaneously add numbers from memory location 0x0400 and 0x0600 and store the sums at R16:R17 and R18:R19 respectively. Do not worry about the overflow.

a) checking if each number is divisible by 5, goes to registers R16 and R17 if divisible by 5 and goes to registers R18 and R19 if not

```
loader:
    LD R15, -X              ; Load number to R20 downwards the stack
    MOV R14, R15            ; Moves value in R16 to check if divisible by 5

; checks if %5=0
D5:                         ; Checks for divisibility by 5
    CP R15, R22             ; Compare R15 and R22 (5)
    BRLO ISNOT5             ; Go to ISNOT5 back if R15 < R22
    CP  R15, R22            ; Compare R15 and R22 (5)
    BREQ IS5                ; Go to IS5 if R15 == R22
    SUB R15, R22            ; R15 = R15 - 5
    CP R15, R22             ; Compare R15 and R22 again
    BRSH D5                 ; Loop back if R15 => R22
```

b) running the program, R16:R17 (divisible by 5) is 7220 (0x1C34) and R18:R19 (not divisible by 5) is 28768 (0x7060)

```
; when %5 != 0 (not divisible)
ISNOT5:
    ST Z+, R14              ; Stores number
    MOV R13, R14            ; Copies stored number
    ADD R19, R14            ; Simultaneously add number (LOW BITS)
    CP R19, R13             ; Compare LOW BIT with loaded number
    BRLO oNot5              ; goes to oIs5 if R19 < R13
    INC R21                 ; Increment counter
    JMP check300second

oNot5:
    INC R18                 ; Increment HIGH BIT
    INC R21                 ; Increment counter
    JMP check300second

; when %5 == 0 (divisible)
IS5:
    ST Y+, R14              ; Stores number
    MOV R13, R14            ; Copies stored number
    ADD R17, R14            ; Simultaneously add number (LOW BITS)
    CP R17, R13             ; Compare LOW BIT with loaded number
    BRLO oIs5               ; goes to oIs5 if R17 < R13
    INC R21                 ; Increment counter
    JMP check300second

oIs5:
    INC R16                 ; Increment HIGH BIT
    INC R21                 ; Increment counter
    JMP check300second
```



Task 4/D: Verify your algorithm and answers using C programming

a) The Code

```
#include <iostream>
#include <cmath>
using namespace std;

int main()
{
  int rem, fivecount = 0, notfivecount = 0;
  int fivesum = 0, notfivesum = 0;
  int array[300];

  //stores 300 numbers
  array[0] = 36; //FIRST ELEMENT (0x22 + 0x02)
  for(int i = 1 ; i < 300 ; i++)
    {
      if(array[i-1] == 254)
          array[i] = 0;
      else
        array[i] = array[i-1] + 2;
    }

  //check if divisible by 5
  for(int j = 0 ; j < 300 ; j++) //TRAVERSE
    {
      rem = array[j] % 5;
      if(rem == 0 && array[j] != 0) //IF DIVISIBLE BY 5
        {
          fivesum += array[j];
          fivecount++;
        }
      else //IF NOT DIVISIBLE BY 5
        {
          notfivesum += array[j];
          notfivecount++;
        }
    }

  //print results
  cout << "#s divisible by 5: " << fivecount << endl;
  cout << "The result for numbers div. by 5: ";
  //cout << fivesum%256 << endl;
  cout << fivesum << endl;

  cout << "#s not divisible by 5: " << notfivecount << endl;
  cout << "The result for numbers not div. by 5: ";
  //cout << notfivesum%256 << endl;
  cout << notfivesum <<endl;
}
```

b) running the code, the outputs matches the hexadecimal results from Task 3/C, 7220 being 0x1C34 and 28768 being 0x7060

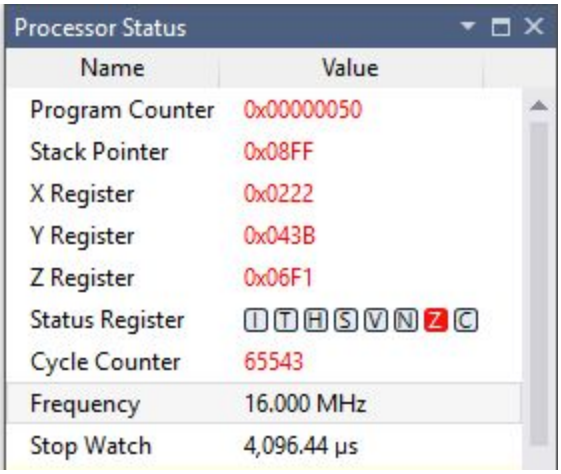
```
[razonj1@bobby CPE301]$ ./a.out
#s divisible by 5: 59
The result for numbers div. by 5: 7220
#s not divisible by 5: 241
The result for numbers not div. by 5: 28768
[razonj1@bobby CPE301]$
```

Task 5/E: Determine the execution time @ 16MHz/#cycles of your algorithm using the simulation.
Execution time (in microseconds) = # of cycles (65543 cycles) / frequency (16 MHz) = 4096.44 us

a) calculations on online scientific calculator

$$\frac{65543}{16} = 4096.4375$$

b) by changing the frequency on Atmel Studios, the stop watch's execution time changed accordingly

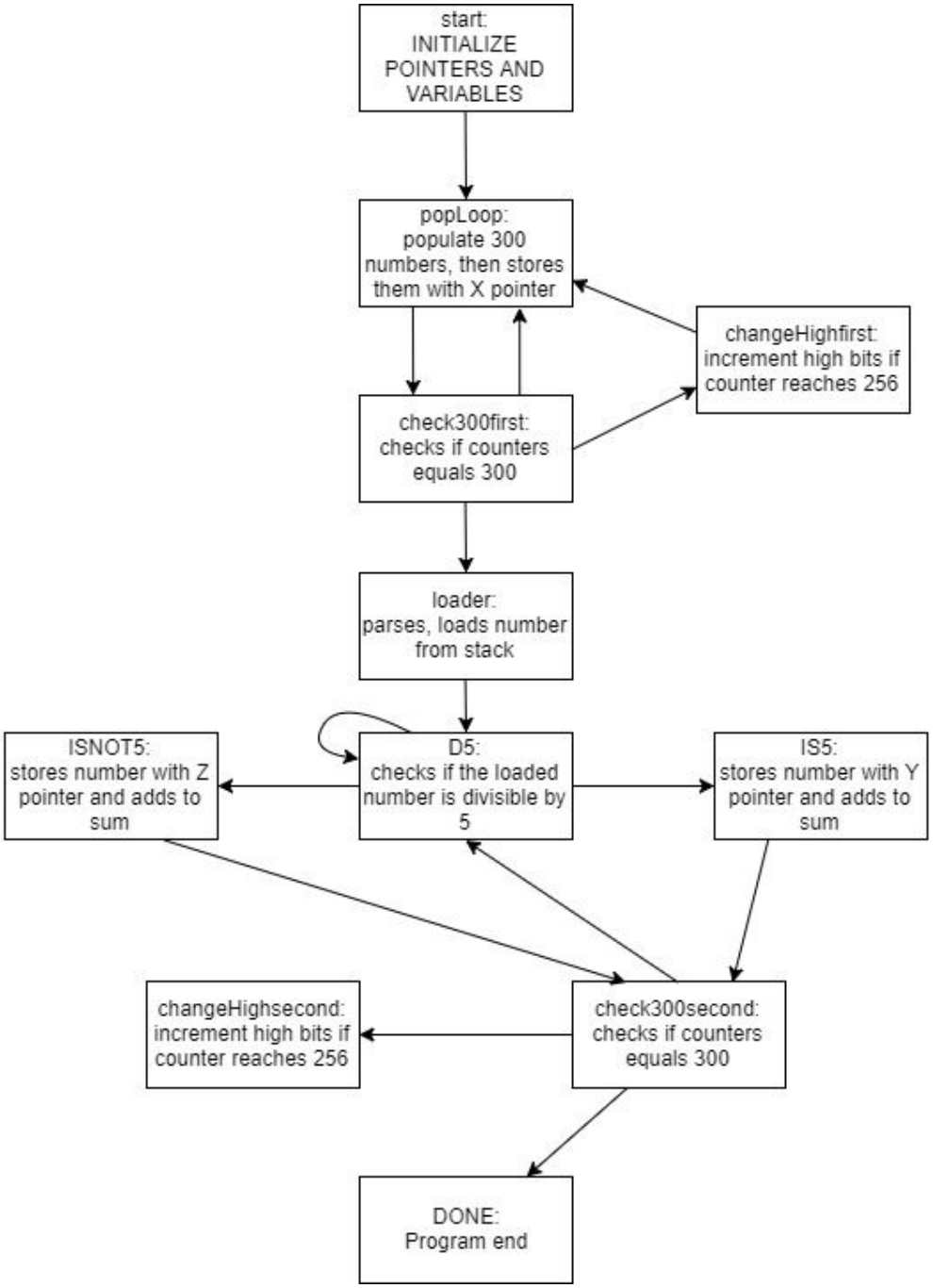


FULL CODE

```
start:
; Declare POINTERS
    LDI XL, LOW(0x0222)
    LDI XH, HIGH(0x0222)
    LDI YL, LOW(0x0400)
    LDI YH, HIGH(0x0400)
    LDI ZL, LOW(0x0600)
    LDI ZH, HIGH(0x0600)

; Declare variables
    CLR R17                 ; Stores total sum of numbers that are divisible by 5, set to 0
    CLR R16                 ; R17 overflow (don't worry about overflow)
    CLR R19                 ; Stores total sum of numbers that are not divisible by 5, set to 0
    CLR R18                 ; R18 overflow (don't worry about overflow)

    CLR R20                 ; Counter register (HIGH), set to 0
    CLR R21                 ; Counter register (LOW), set to 0
    LDI R23, HIGH(300)      ; Immediate value 300 H (0x01), count checker
    LDI R24, LOW(300)       ; Immediate value 300 L (0x2c), count checker

    CLR R22                 ; R22 = 0
    LDI R22, LOW(0x0222)    ; R22 = 0x22
    ADD R25, R22            ; R25 = R25 + R22
    LDI R22, HIGH(0x0222)   ; R22 = 0x02

; Populate and store 300 numbers
popLOOP:
    ADD R25, R22            ; R25 += R22
    ST X+, R25              ; Store number
    INC R21                 ; increment counter (low)
    JMP check300first
```

```
; Increment higher bits
changeHighfirst:
    INC R20                 ; increment higher bit
    CLR R21                 ; restarts lower bits
    JMP popLOOP

; Checks if counter == 300
check300first:
    CPI R21, 0x00           ; Check to increment high bit
    BREQ changeHighfirst
    CP R24, R21             ; Compare LOW(300) and R21
    BRNE popLOOP
    CP R23, R20             ; Compare HIGH(300) and R20
    BRNE popLOOP

    CLR R20                 ; clear counter(high)
    CLR R21                 ; clear counter(low)
    CLR R22                 ; clear R22
    LDI R22, 0x05           ; load a 5 to check if divisible

; Loads next number number in stack
loader:
    LD R15, -X              ; Load number to R20 downwards the stack
    MOV R14, R15            ; Moves value in R16 to check if divisible by 5

; checks if %5=0
D5:                         ; Checks for divisibility by 5
    CP R15, R22             ; Compare R15 and R22 (5)
    BRLO ISNOT5             ; Go to ISNOT5 back if R15 < R22
    CP  R15, R22            ; Compare R15 and R22 (5)
    BREQ IS5                ; Go to IS5 if R15 == R22
    SUB R15, R22            ; R15 = R15 - 5
    CP R15, R22             ; Compare R15 and R22 again
    BRSH D5                 ; Loop back if R15 => R22

; when %5 != 0 (not divisible)
ISNOT5:
    ST Z+, R14              ; Stores number
    MOV R13, R14            ; Copies stored number
    ADD R19, R14            ; Simultaneously add number (LOW BITS)
    CP R19, R13             ; Compare LOW BIT with loaded number
    BRLO oNot5              ; goes to oIs5 if R19 < R13
    INC R21                 ; Increment counter
    JMP check300second



oNot5:
    INC R18                 ; Increment HIGH BIT
    INC R21                 ; Increment counter
    JMP check300second

; when %5 == 0 (divisible)
IS5:
    ST Y+, R14              ; Stores number
    MOV R13, R14            ; Copies stored number
    ADD R17, R14            ; Simultaneously add number (LOW BITS)
    CP R17, R13             ; Compare LOW BIT with loaded number
    BRLO oIs5               ; goes to oIs5 if R17 < R13
    INC R21                 ; Increment counter
    JMP check300second

oIs5:
    INC R16                 ; Increment HIGH BIT
    INC R21                 ; Increment counter
    JMP check300second

; Increments higher bits
changeHighsecond:
    INC R20                 ; increment higher bit
    CLR R21                 ; restarts lower bits
    JMP loader

; Checks if counter == 300
check300second:
    CPI R21, 0x00           ; Check to increment high bit
    BREQ changeHighsecond   ; counter reaches 256
    CP R24, R21             ; Compare LOW(300) and R21
    BRNE loader             ; loop back if R24 != R21
    CP R23, R20             ; Compare HIGH(300) and R20
    BRNE loader             ; loop back if R23 != R20

DONE:
    NOP                     ; Program end
```

FLOW CHART



GITHUB LINK: https://github.com/JeffinVegas/EmbSys.git

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"*This assignment submission is my own, original work*".
Jeffrey Razon