EC-210

MICROPROCESSORS LAB

LAB-7

UTKARSH MAHAJAN 201EC164

ARNAV RAJ 201EC109

Objective: To understand division and code conversion operations.

Exercise:

7.1] Write a program to divide

(a) 32 bit number by 16 bit number.

->

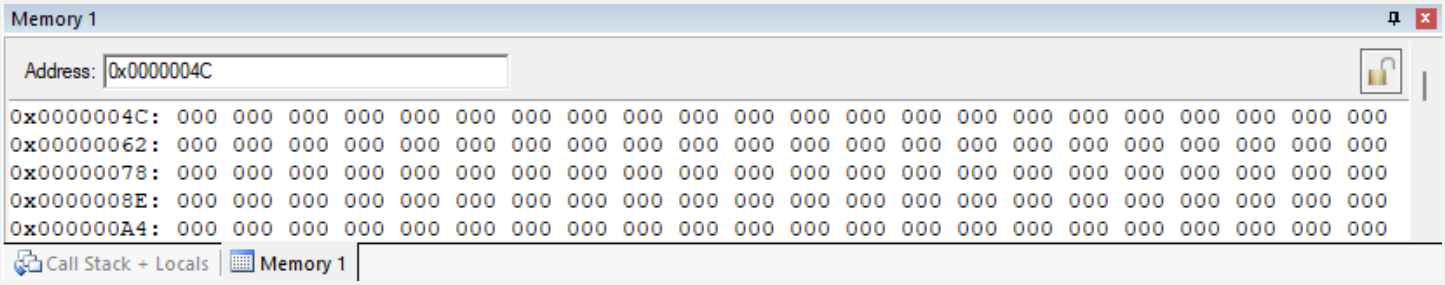
Repeated subtraction:

Source Code:

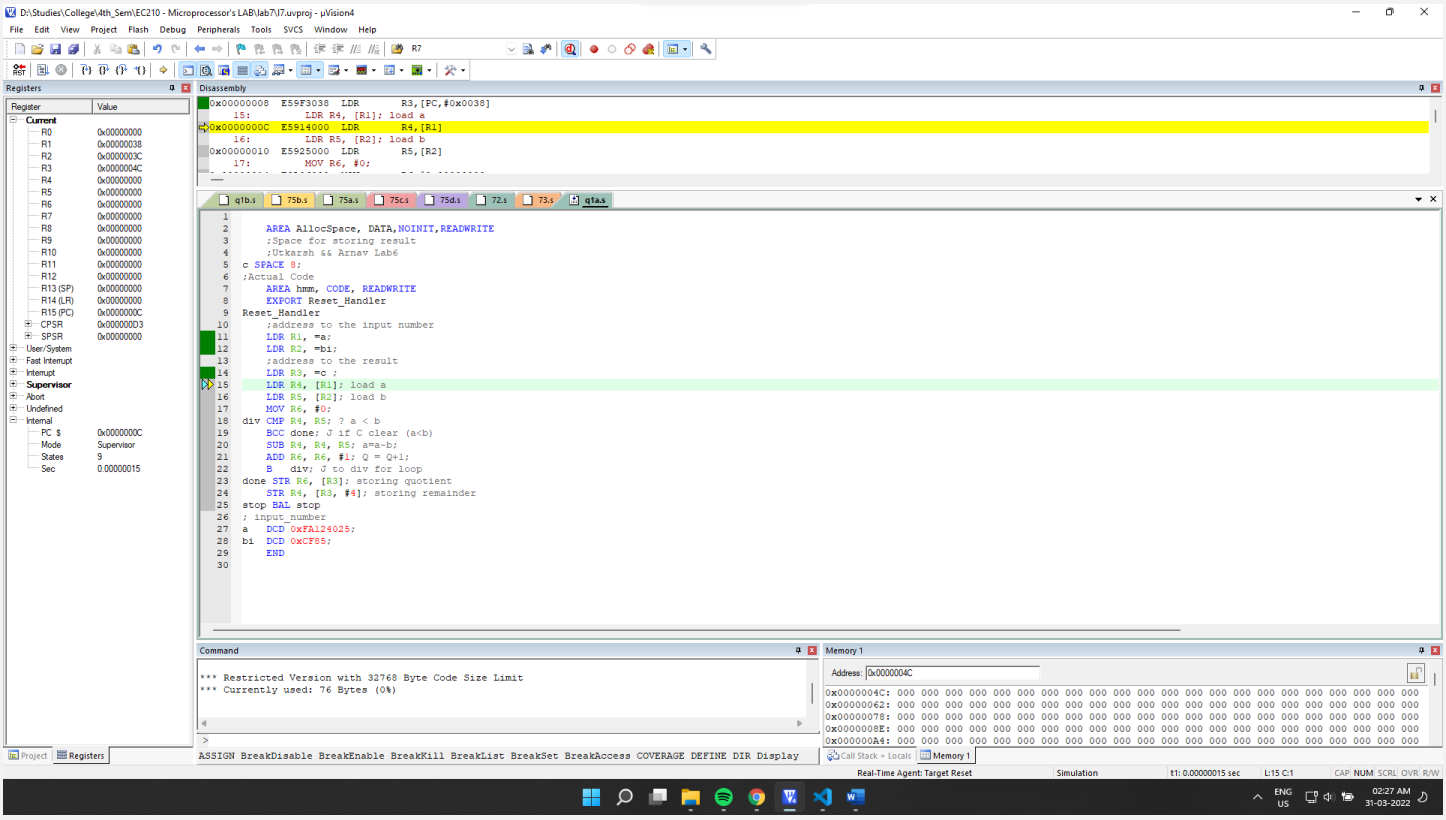
```
    AREA AllocSpace, DATA,NOINIT,READWRITE
    ;Space for storing result
    ;Utkarsh && Arnav Lab6
c SPACE 8;
;Actual Code
    AREA hmm, CODE, READWRITE
    EXPORT Reset_Handler
Reset_Handler
    ;address to the input number
    LDR R1, =a;
    LDR R2, =bi;
    ;address to the result
    LDR R3, =c ;
    LDR R4, [R1]; load a
    LDR R5, [R2]; load b
    MOV R6, #0;
div CMP R4, R5; ? a < b
    BCC done; J if C clear (a<b)
    SUB R4, R4, R5; a=a-b;
    ADD R6, R6, #1; Q = Q+1;
    B   div; J to div for loop
done STR R6, [R3]; storing quotient
    STR R4, [R3, #4]; storing remainder
stop BAL stop
; input_number
a   DCD 0xFA124025;
bi  DCD 0xCF85;
    END
```

Debugging:

Initial Memory: (after getting the address through register)



Setup:

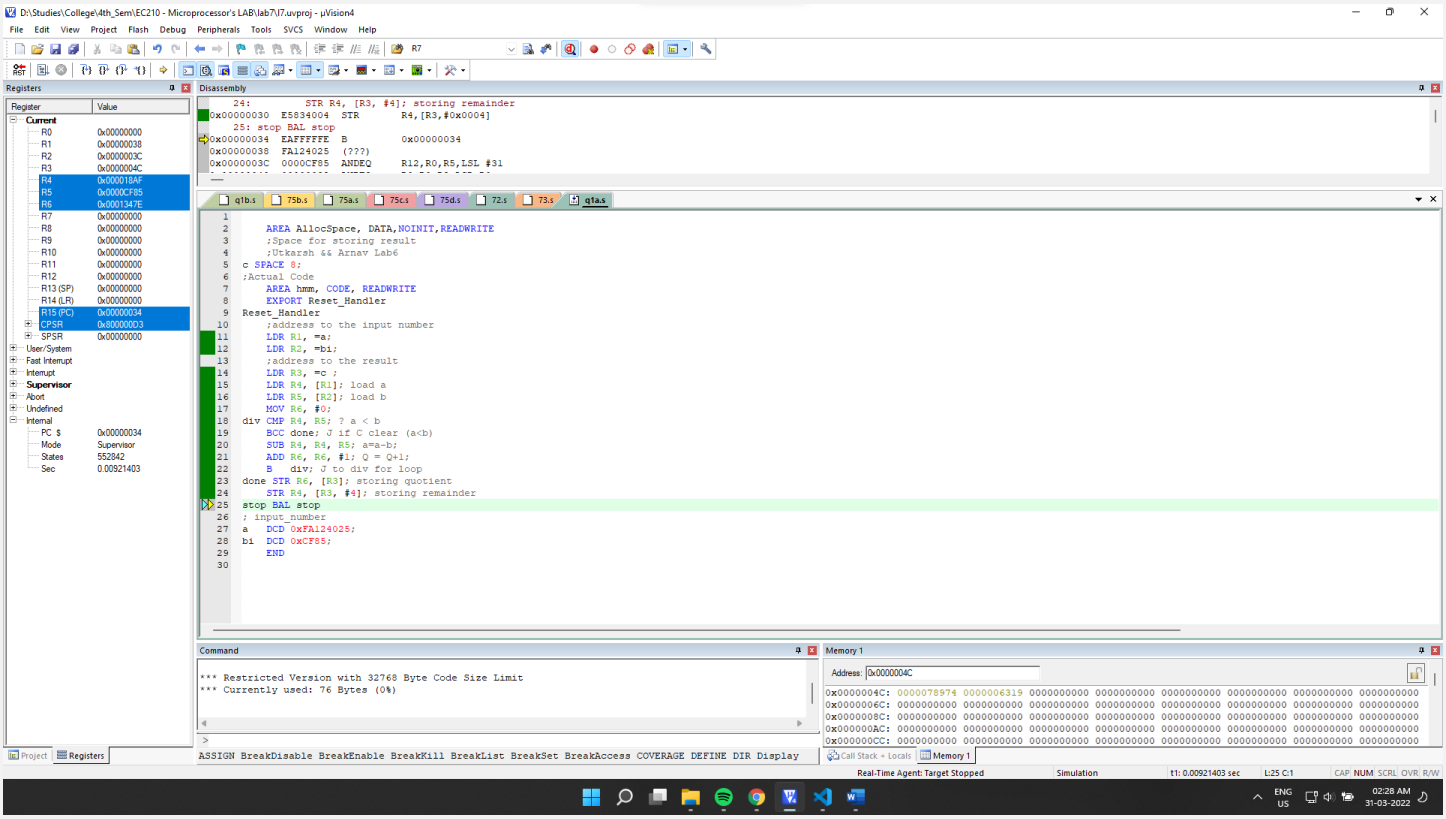


Inputs: a= 0xFA124025(4195500069), b=0xCF85(53125)

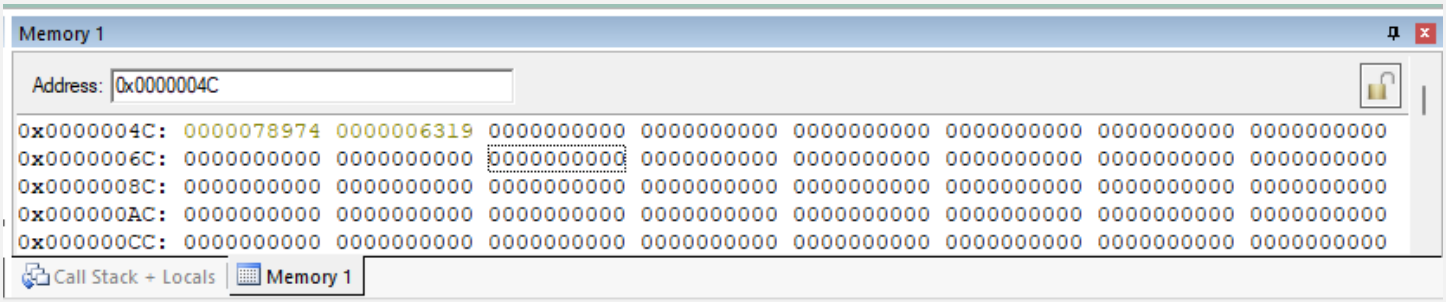
Expected results: 78974.1189459

Which is Q= 78974, R=6319

Final Output:



Final Memory: (in decimal)



Comparing the final memory with expected result, we can see that our code is correct.

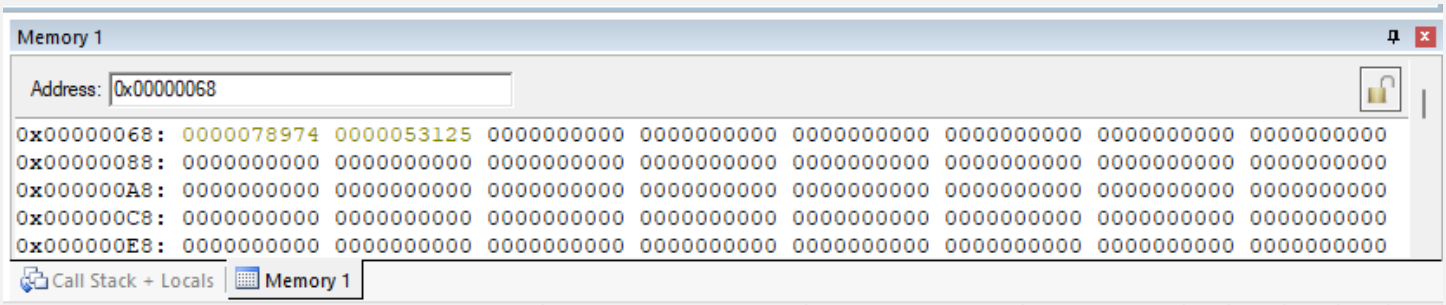
shift & subtract Method:

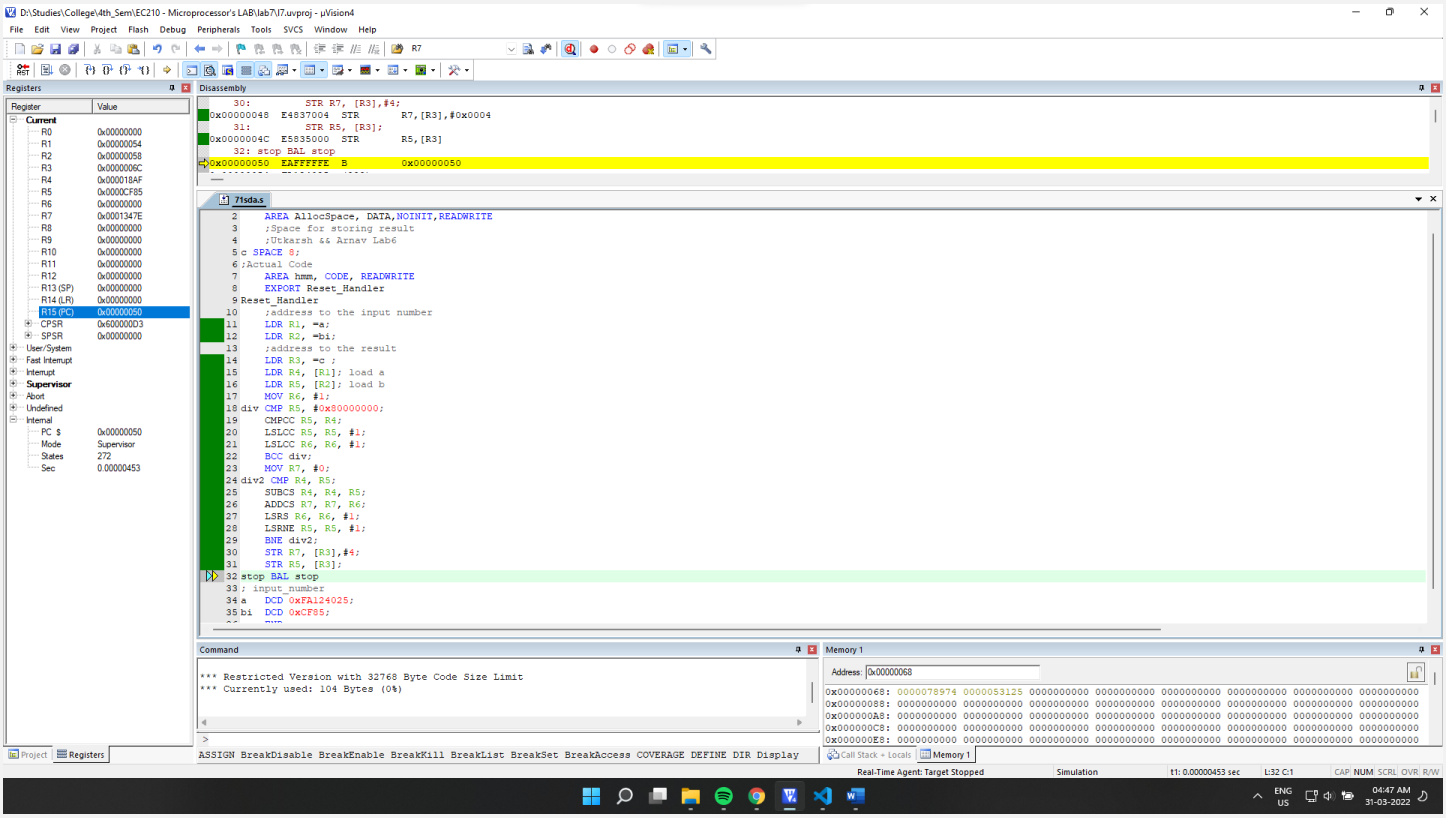
Source Code:

```
    AREA AllocSpace, DATA,NOINIT,READWRITE
    ;Space for storing result
    ;Utkarsh && Arnav Lab6
c SPACE 8;
;Actual Code
```

```
    AREA hmm, CODE, READWRITE
    EXPORT Reset_Handler
Reset_Handler
    ;address to the input number
    LDR R1, =a;
    LDR R2, =bi;
    ;address to the result
    LDR R3, =c ;
    LDR R4, [R1]; load a
    LDR R5, [R2]; load b
    MOV R6, #1;
div CMP R5, #0x80000000;
    CMPCC R5, R4;
    LSLCC R5, R5, #1;
    LSLCC R6, R6, #1;
    BCC div;
    MOV R7, #0;
div2 CMP R4, R5;
    SUBCS R4, R4, R5;
    ADDCS R7, R7, R6;
    LSRS R6, R6, #1;
    LSRNE R5, R5, #1;
    BNE div2;
    STR R7, [R3],#4;
    STR R5, [R3];
stop BAL stop
; input_number
a   DCD 0xFA124025;
bi  DCD 0xCF85;
    END
```

Final Output:





It matches the final output.

Execution Time:

Subtraction method: 0.00000015sec

Shift and divide: 0.00000453sec

For smaller values, shift and divide seems to take more time.

(b) 64 bit number by 32 bit number

->

Repeated subtraction:

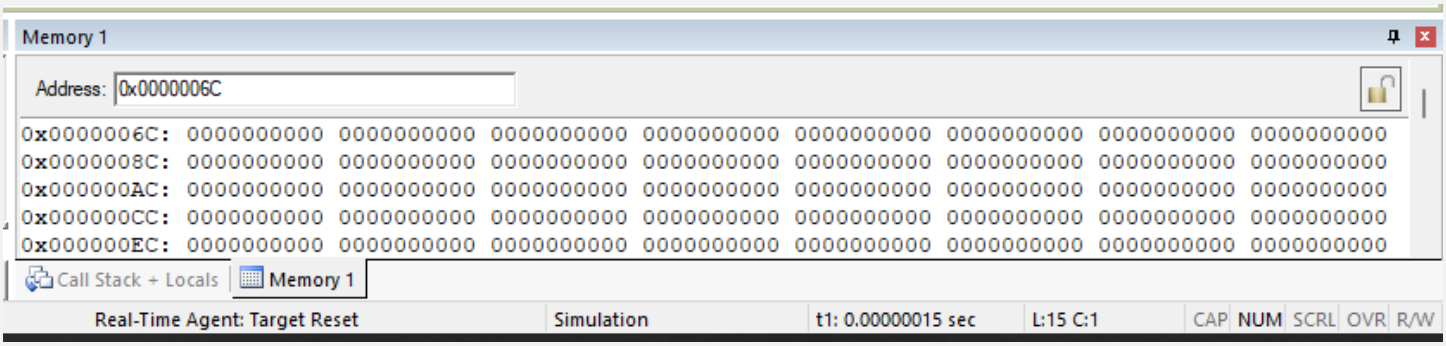
Source Code:

```
    AREA AllocSpace, DATA,NOINIT,READWRITE
    ;Space for storing result
    ;Utkarsh && Arnav Lab6
c SPACE 8;
```

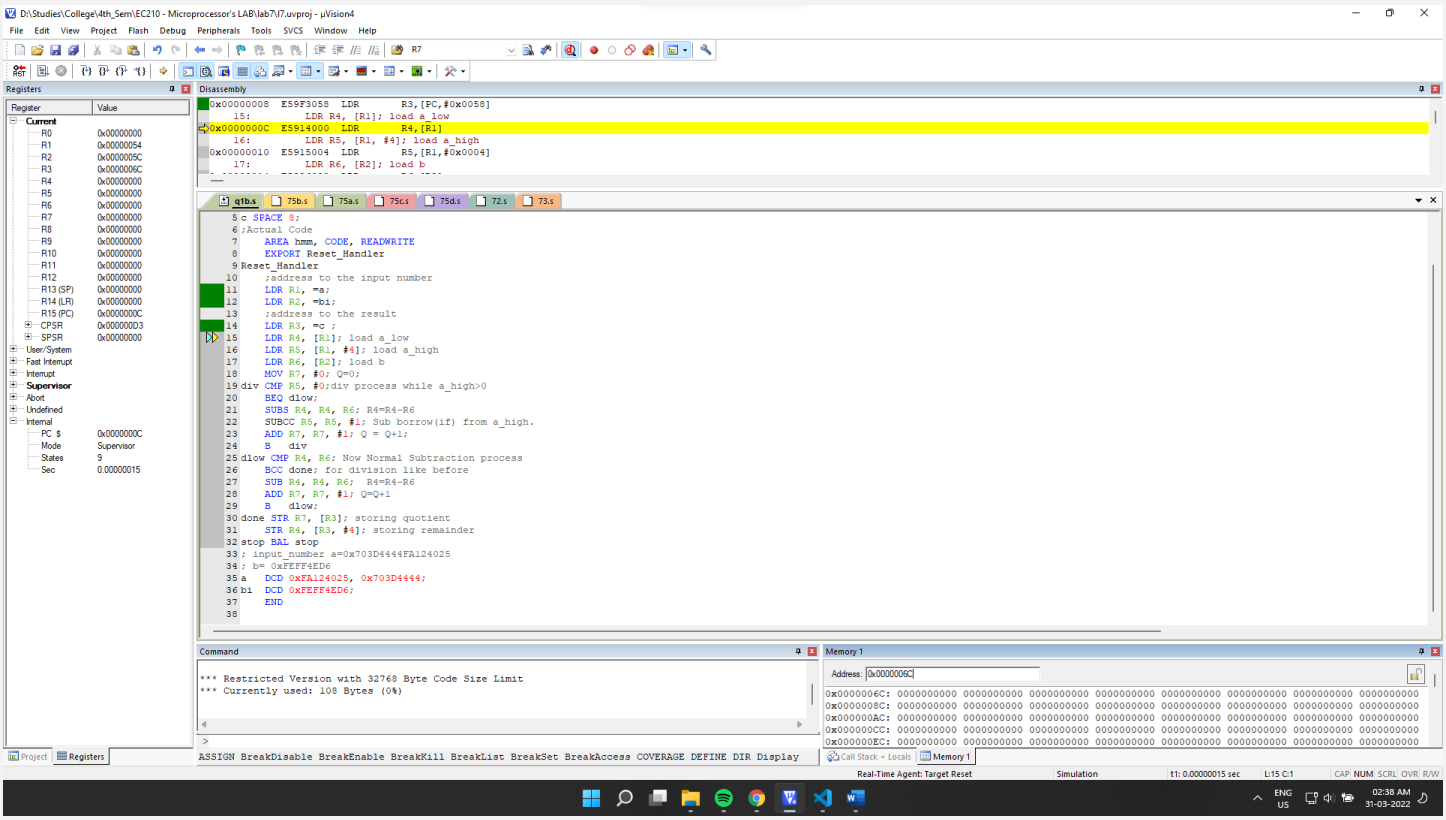
```
;Actual Code
    AREA hmm, CODE, READWRITE
    EXPORT Reset_Handler
Reset_Handler
    ;address to the input number
    LDR R1, =a;
    LDR R2, =bi;
    ;address to the result
    LDR R3, =c ;
    LDR R4, [R1]; load a_low
    LDR R5, [R1, #4]; load a_high
    LDR R6, [R2]; load b
    MOV R7, #0; Q=0;
div CMP R5, #0;div process while a_high>0
    BEQ dlow;
    SUBS R4, R4, R6; R4=R4-R6
    SUBCC R5, R5, #1; Sub borrow(if) from a_high.
    ADD R7, R7, #1; Q = Q+1;
    B   div
dlow CMP R4, R6; Now Normal Subtraction process
    BCC done; for division like before
    SUB R4, R4, R6;  R4=R4-R6
    ADD R7, R7, #1; Q=Q+1
    B   dlow;
done STR R7, [R3]; storing quotient
    STR R4, [R3, #4]; storing remainder
stop BAL stop
; input_number a=0x703D4444FA124025
; b= 0xFEFF4ED6
a   DCD 0xFA124025, 0x703D4444;
bi  DCD 0xFEFF4ED6;
    END
```

Debugging:

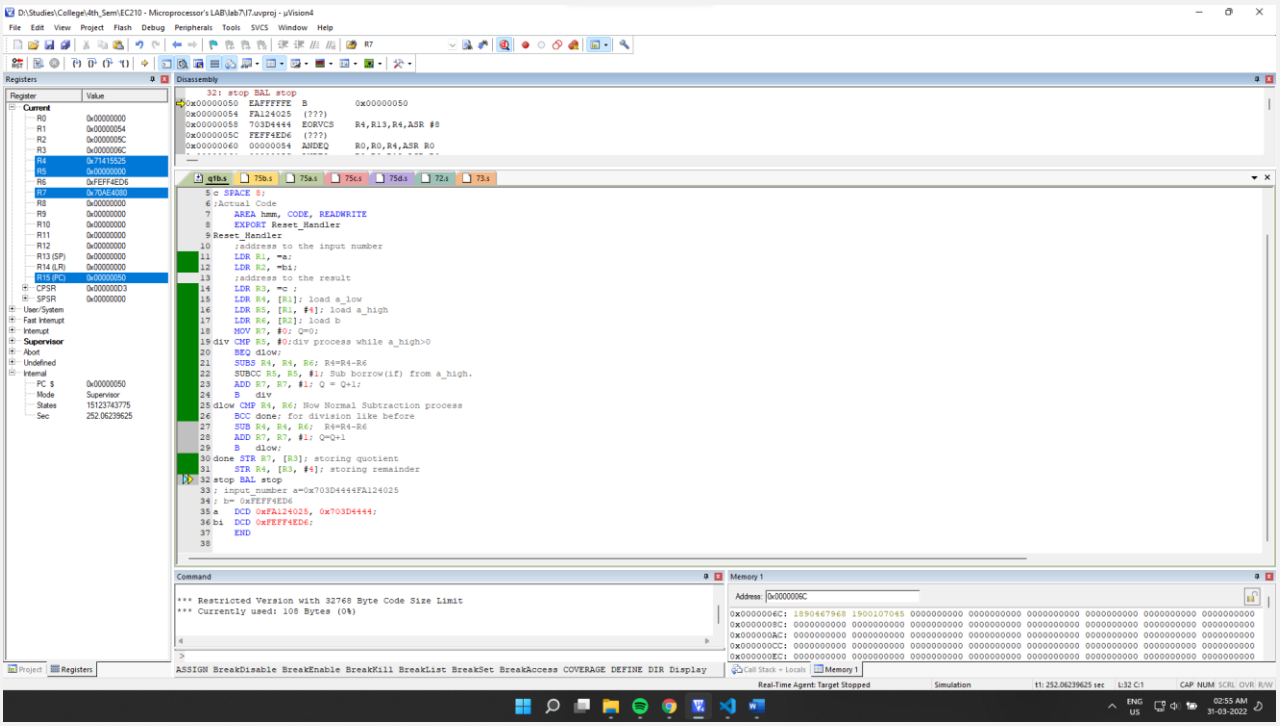
Initial Memory: (after getting the address through register)



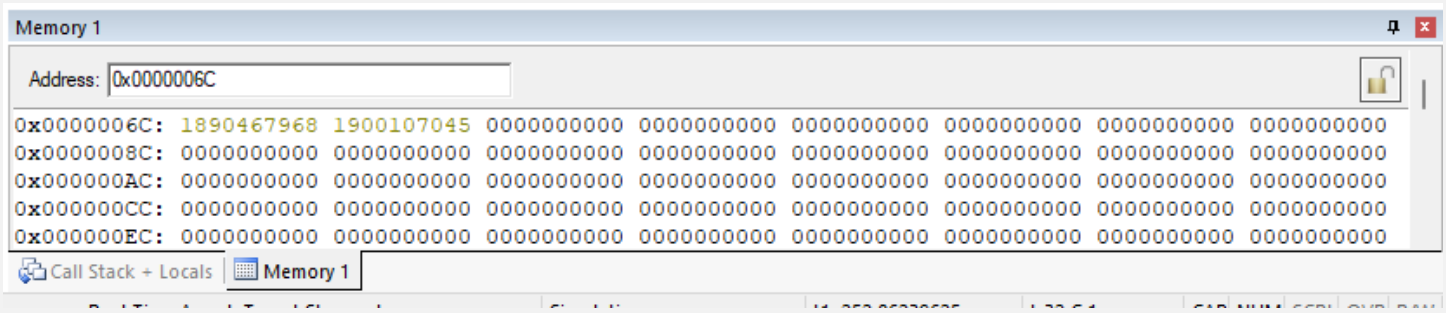
Setup:



Final Output:

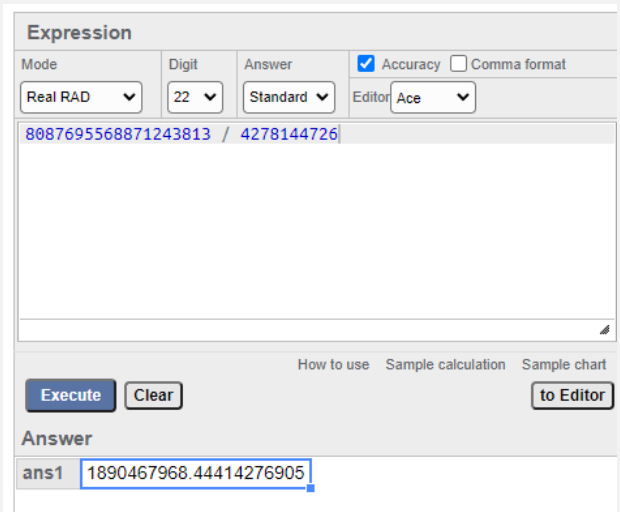


Final Memory:



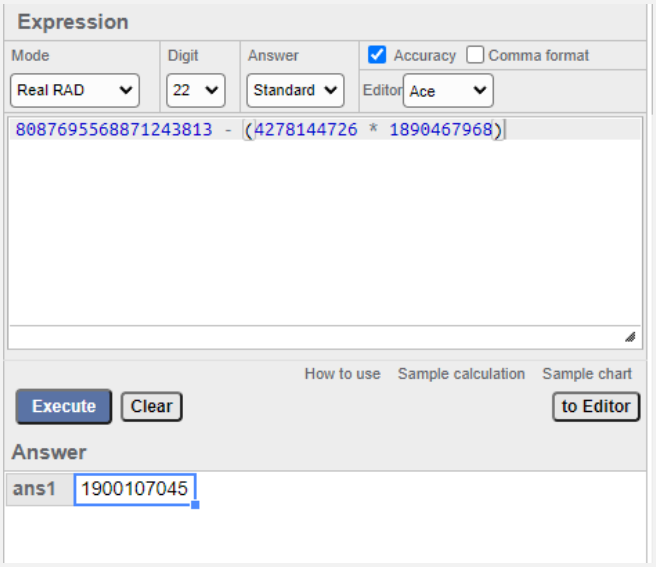
0x703D4444FA124025/ 0xFEFF4ED6 = 8087695568871243813/ 4278144726

Comparing the results with an online precise calculator: (https://keisan.casio.com/calculator)



We can see that our quotient matches.

Now for the remainder:



We can see that even it matches. Hence our result is correct.

7.2] Write a program that takes a 16 bit Hex number and converts it into its BCD equivalent.

->

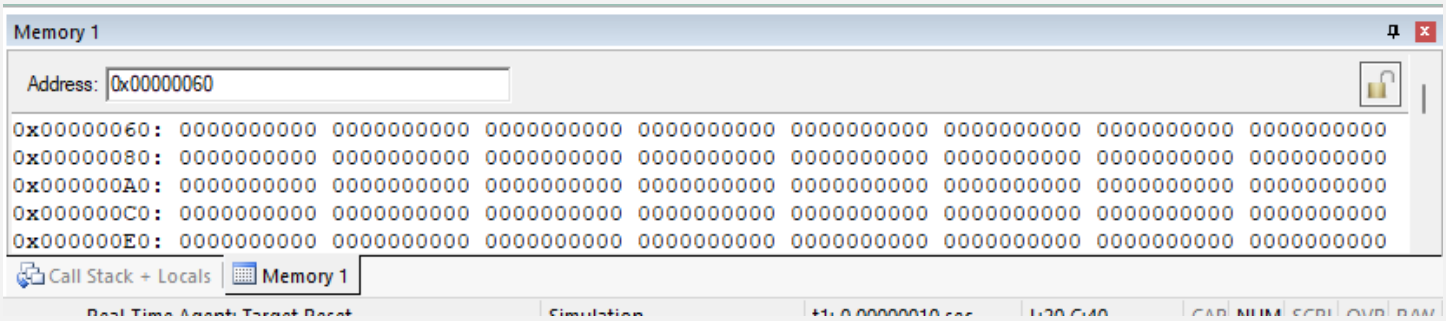
Source Code:

```
    AREA AllocSpace, DATA,NOINIT,READWRITE
    ;Space for result
array SPACE 1024;
;Actual Code
    AREA hmm, CODE, READWRITE
    EXPORT Reset_Handler
Reset_Handler
    ;address to the input number
    LDR R1, =inputnumber ;
    ;address for result
    LDR R2, =array;
    MOV R12, R2;
    ; load the  input number from memory
    LDR R4, [R1];
    ; Getting the last bit
```

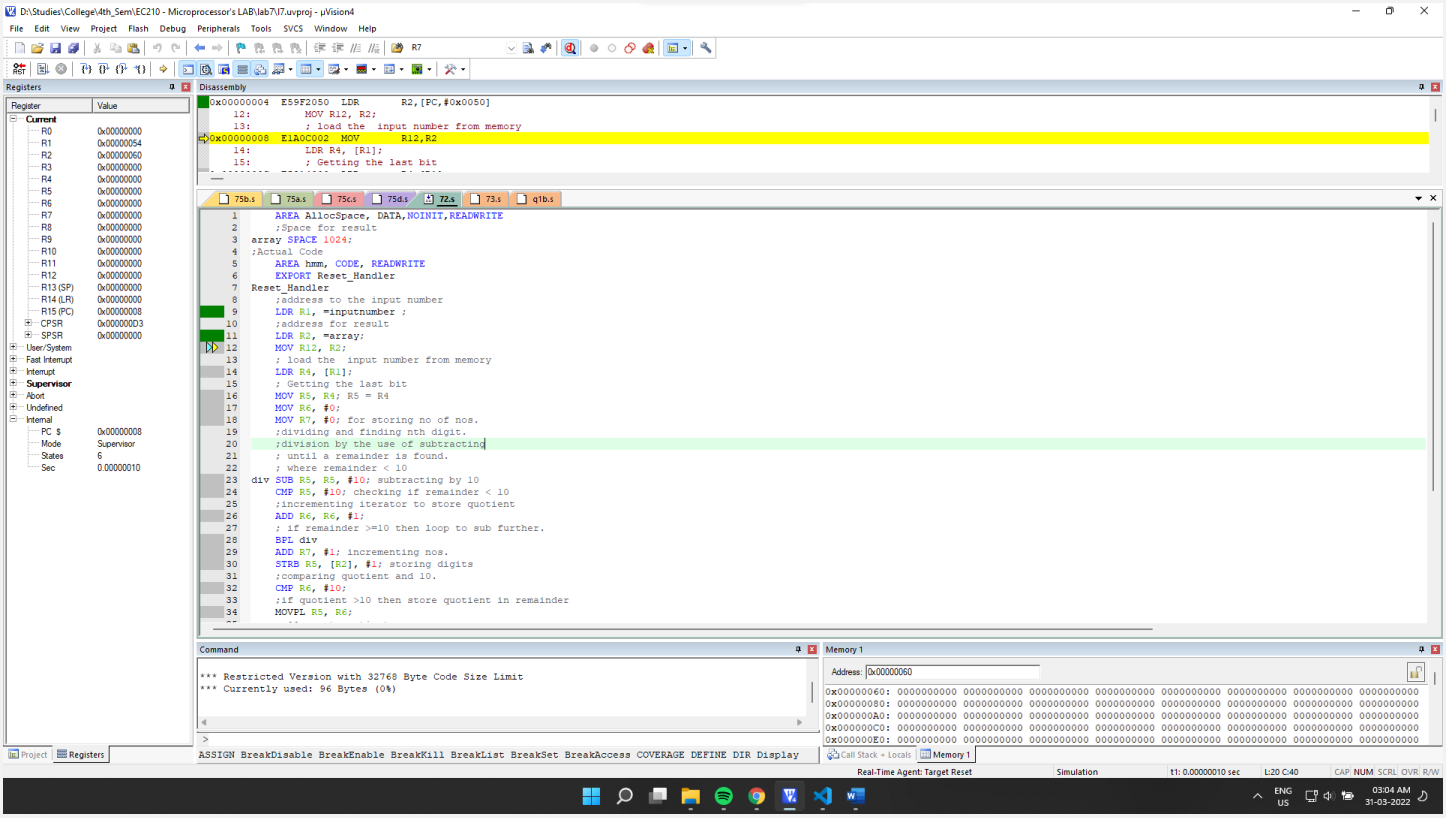
```
    MOV R5, R4; R5 = R4
    MOV R6, #0;
    MOV R7, #0; for storing no of nos.
    ;dividing and finding nth digit.
    ;division by the use of subtracting
    ; until a remainder is found.
    ; where remainder < 10
div SUB R5, R5, #10; subtracting by 10
    CMP R5, #10; checking if remainder < 10
    ;incrementing iterator to store quotient
    ADD R6, R6, #1;
    ; if remainder >=10 then loop to sub further.
    BPL div
    ADD R7, #1; incrementing nos.
    STRB R5, [R2], #1; storing digits
    ;comparing quotient and 10.
    CMP R6, #10;
    ;if quotient >10 then store quotient in remainder
    MOVPL R5, R6;
    ; && reset quotient
    MOVPL R6, #0;
    ; && loop again
    BPL div;
    ; check if quotient is zero
    CMP R6, #0;
    ; increment no of digits counter if no
    ADDNE R7, #1;
    ; &&  store it in R2 if no.
    STRBNE R6, [R2]; storing last digit
    ;
stop BAL stop
; input_number
inputnumber DCD 0xFABC;64188
    END
```

Debugging:

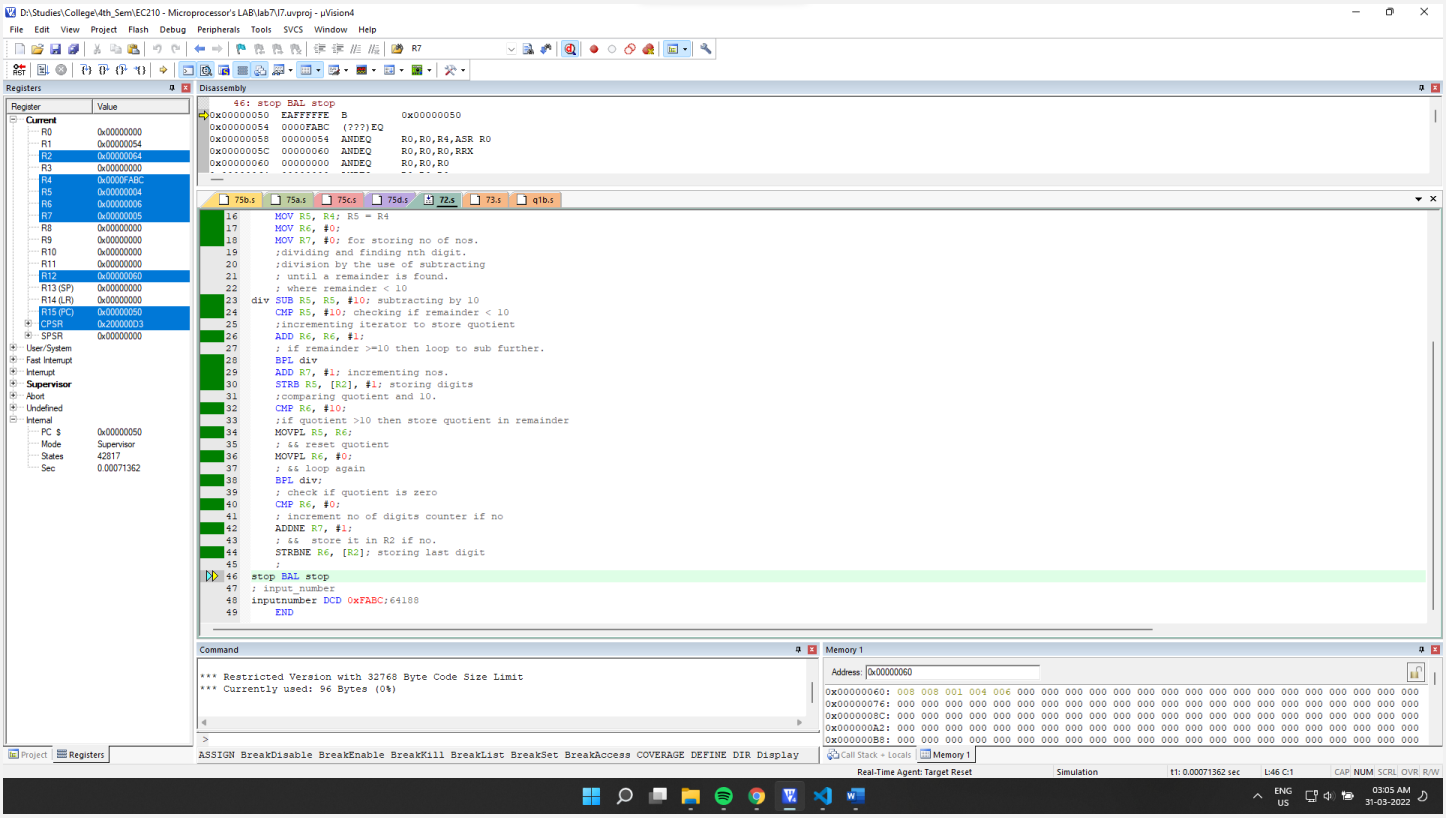
Initial Memory: (after getting the address through register)



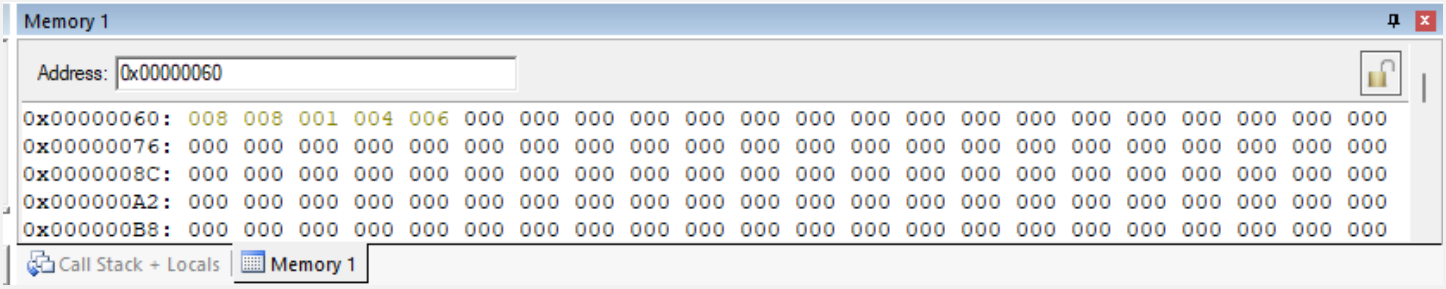
Setup:



Final Output:



Final Memory:



We can see that for our input 0xFABC (64188 in decimal) the BCD values stored matches.

7.3] Write a program that takes an 4 digit BCD number and converts it into is Hex equivalent.

->

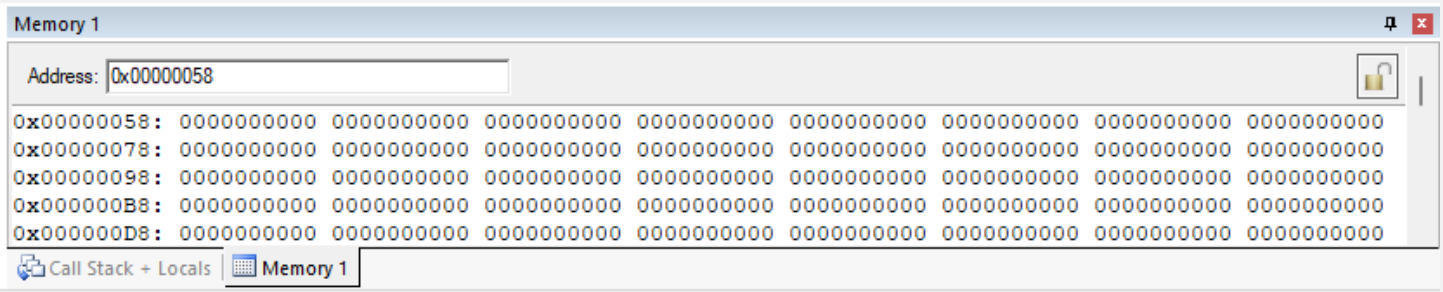
Source Code:

```
AREA AllocSpace, DATA,NOINIT,READWRITE
;Space for storing result
;Utkarsh && Arnav Lab6
```

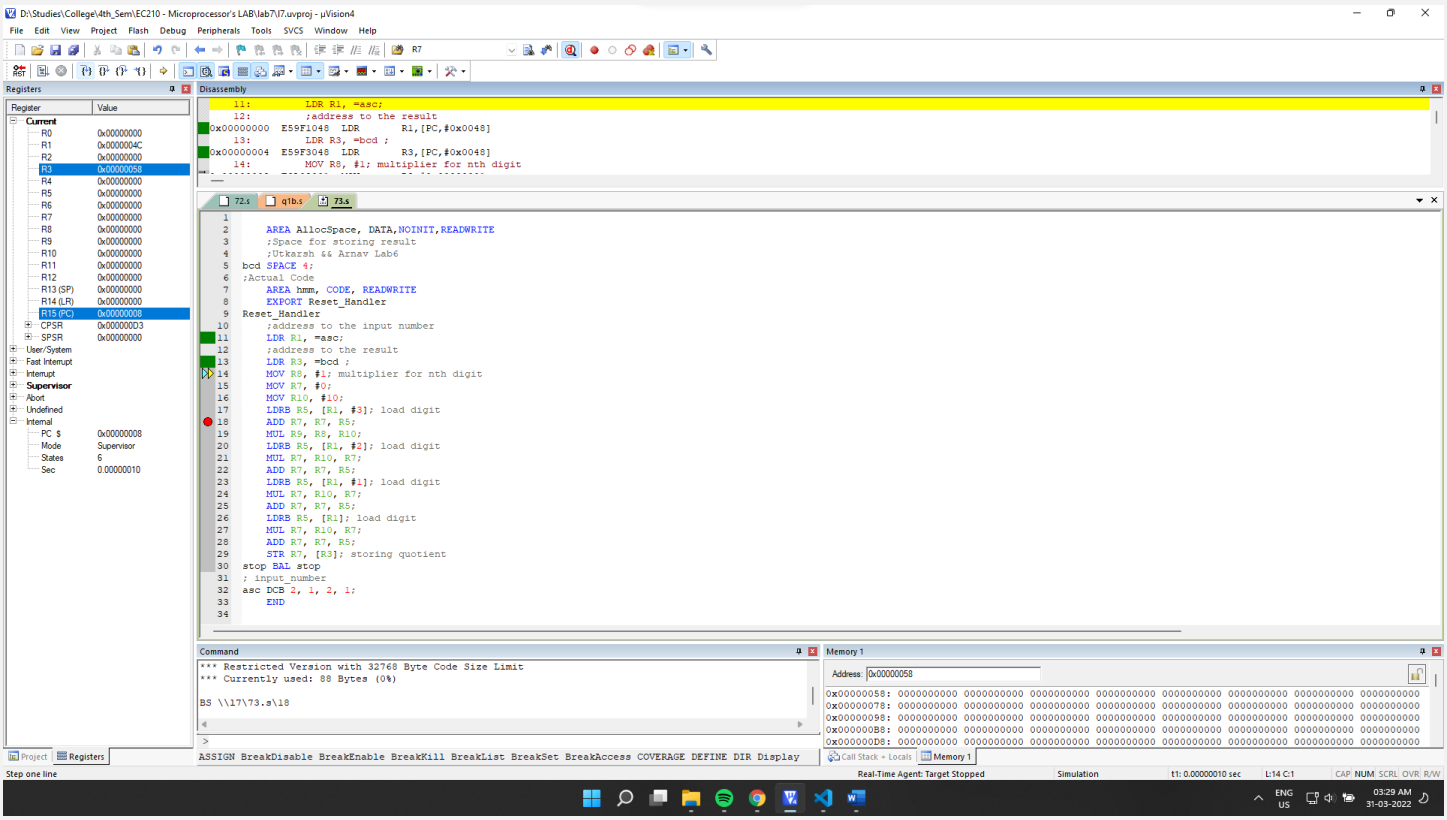
```
bcd SPACE 4;
;Actual Code
    AREA hmm, CODE, READWRITE
    EXPORT Reset_Handler
Reset_Handler
    ;address to the input number
    LDR R1, =asc;
    ;address to the result
    LDR R3, =bcd ;
    MOV R8, #1; multiplier for nth digit
    MOV R7, #0;
    MOV R10, #10;
    LDRB R5, [R1, #3]; load digit
    ADD R7, R7, R5;
    MUL R9, R8, R10;
    LDRB R5, [R1, #2]; load digit
    MUL R7, R10, R7;
    ADD R7, R7, R5;
    LDRB R5, [R1, #1]; load digit
    MUL R7, R10, R7;
    ADD R7, R7, R5;
    LDRB R5, [R1]; load digit
    MUL R7, R10, R7;
    ADD R7, R7, R5;
    STR R7, [R3]; storing quotient
stop BAL stop
; input_number
asc DCB 2, 1, 2, 1;
    END
```

Debugging:

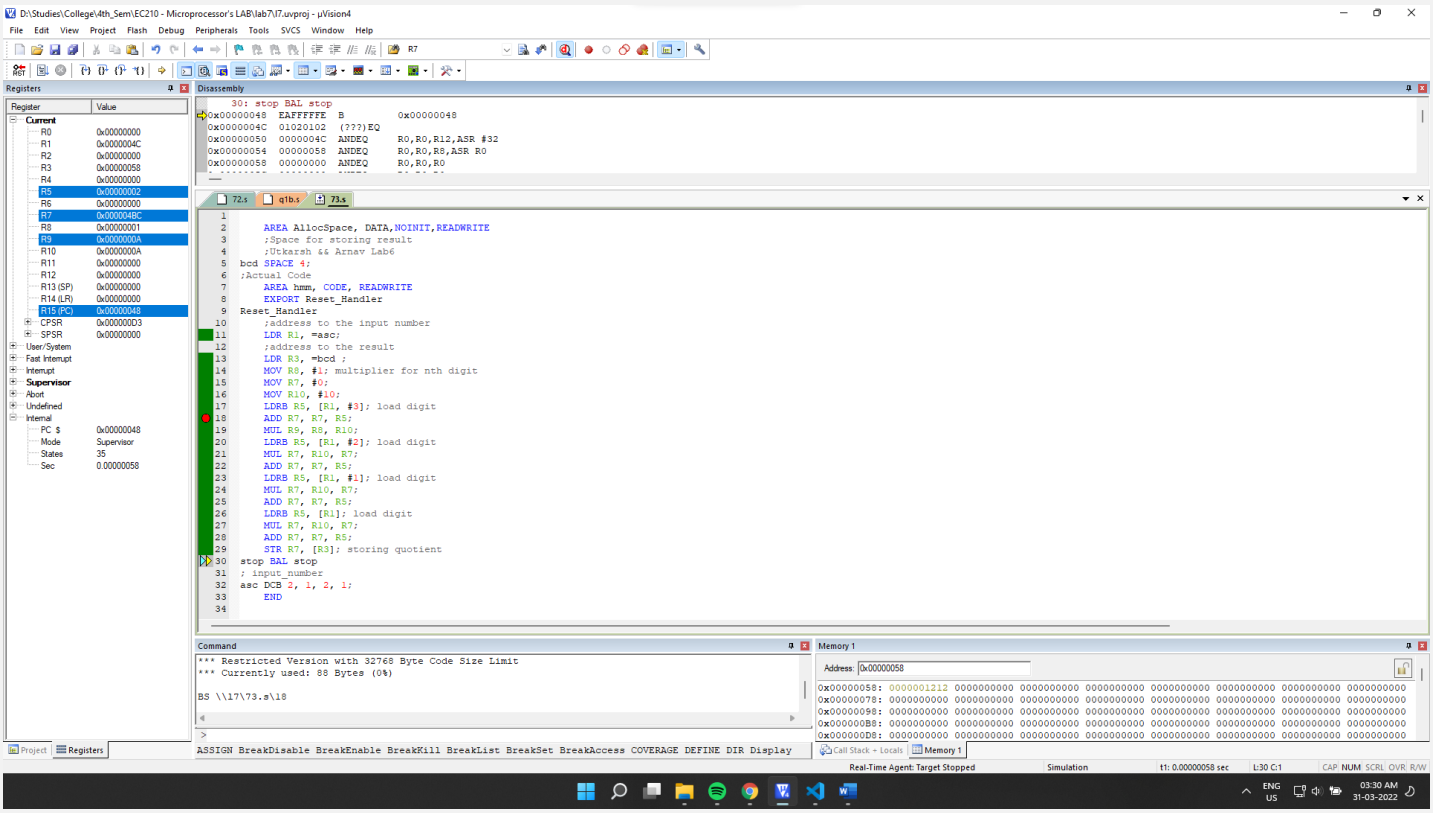
Initial Memory: (after getting the address through register)



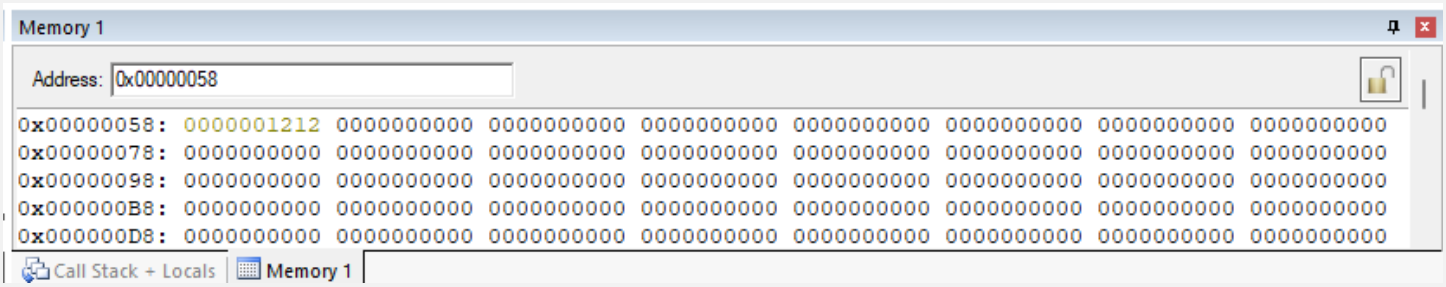
Setup:



Final Output:



Final Memory:



We can see that the output matches our input 1212 which was in BCD format.

7.4] Perform addition of two 8 digit BCD numbers and give the result in BCD.

->

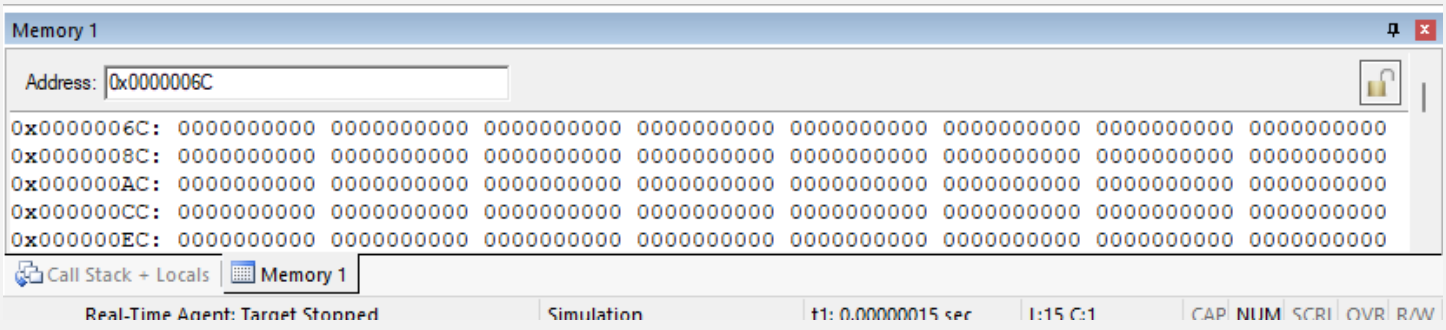
Source Code:

```
    AREA AllocSpace, DATA,NOINIT,READWRITE
    ;Utkarsh && Arnav Lab6
    ;Space for storing result
z SPACE 9;
;Actual Code
    AREA hmm, CODE, READWRITE
```

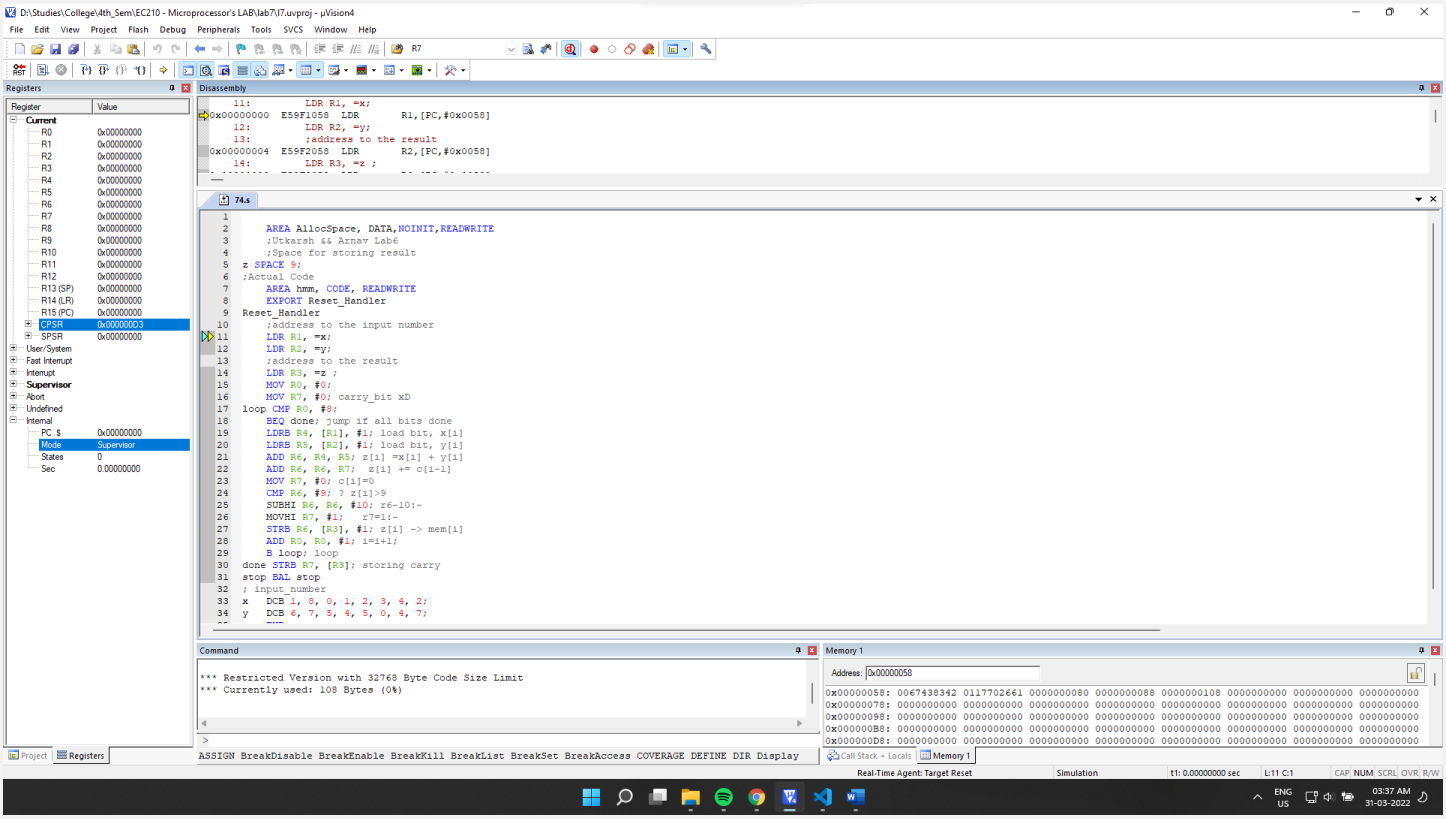
```
    EXPORT Reset_Handler
Reset_Handler
    ;address to the input number
    LDR R1, =x;
    LDR R2, =y;
    ;address to the result
    LDR R3, =z ;
    MOV R0, #0;
    MOV R7, #0; carry_bit xD
loop CMP R0, #8;
    BEQ done; jump if all bits done
    LDRB R4, [R1], #1; load bit, x[i]
    LDRB R5, [R2], #1; load bit, y[i]
    ADD R6, R4, R5; z[i] =x[i] + y[i]
    ADD R6, R6, R7;  z[i] += c[i-1]
    MOV R7, #0; c[i]=0
    CMP R6, #9; ? z[i]>9
    SUBHI R6, R6, #10; r6-10:-
    MOVHI R7, #1;   r7=1:-
    STRB R6, [R3], #1; z[i] -> mem[i]
    ADD R0, R0, #1; i=i+1;
    B loop; loop
done STRB R7, [R3]; storing carry
stop BAL stop
; input_number
x   DCB 1, 8, 0, 1, 2, 3, 4, 2;
y   DCB 6, 7, 5, 4, 5, 0, 4, 7;
    END
```

Debugging:

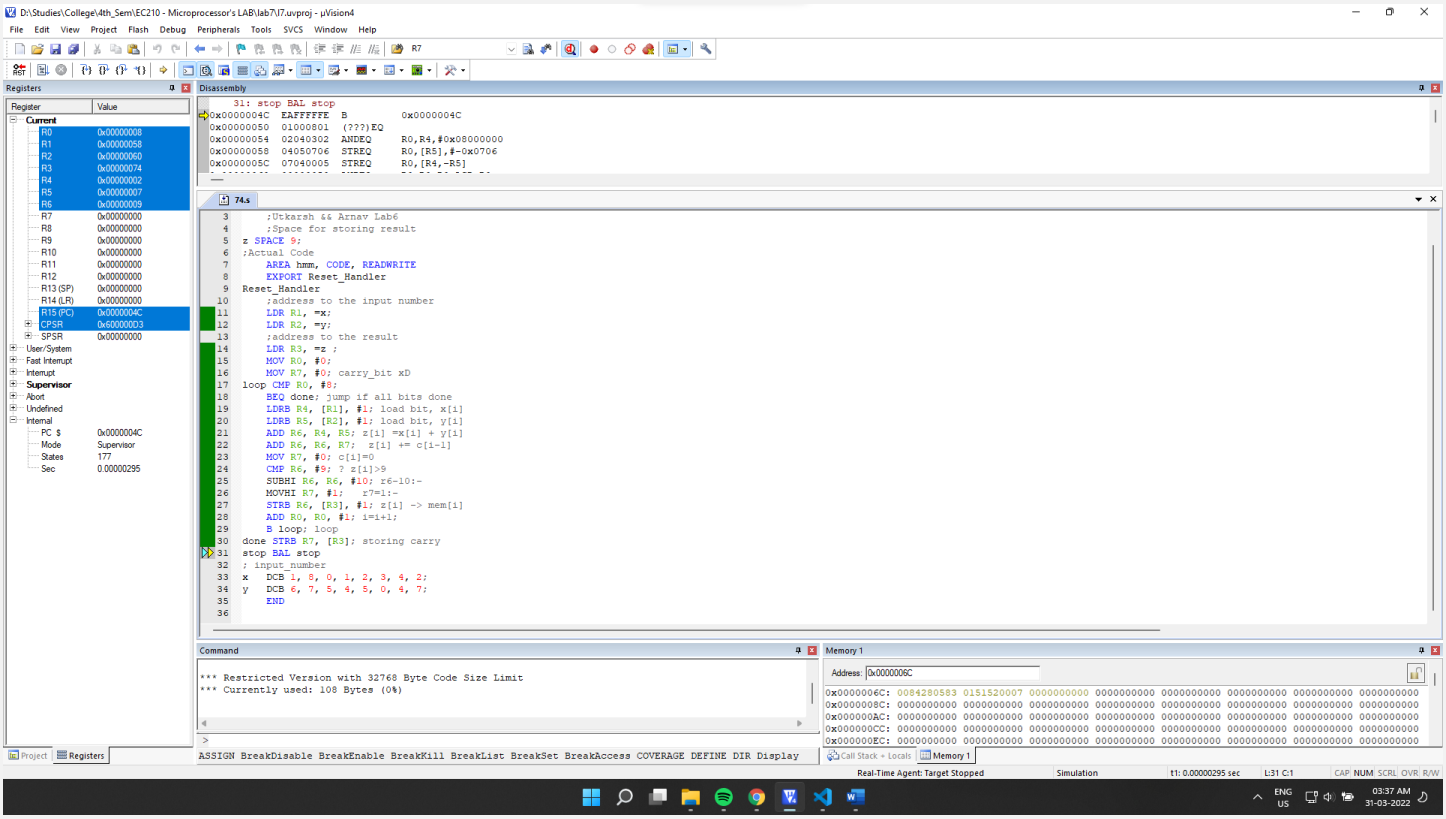
Initial Memory: (after getting the address through register)



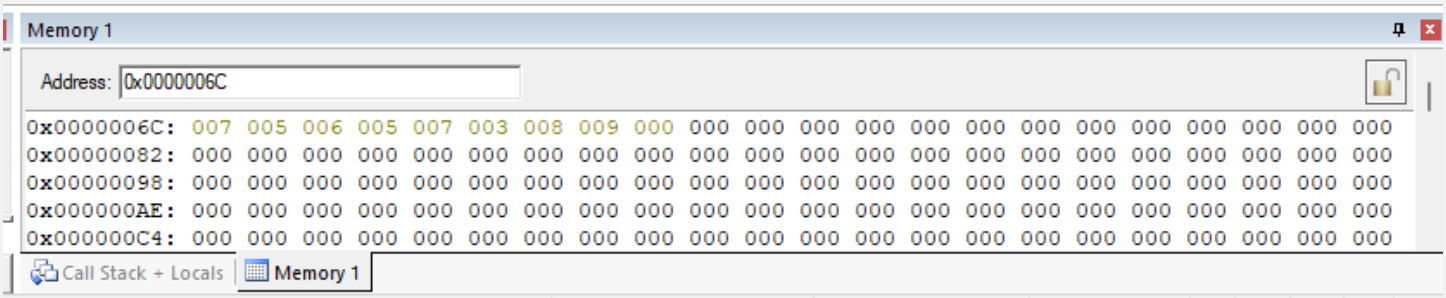
Setup:



Final Output:



Final Memory:



We can see that for our input 24321081 + 74054576 (in BCD)

=98375657, which matches our output.

7.5] Write a program to convert a given (Note: Consider BCD and HX to 4 digits no)

(a) ASCII to BCD

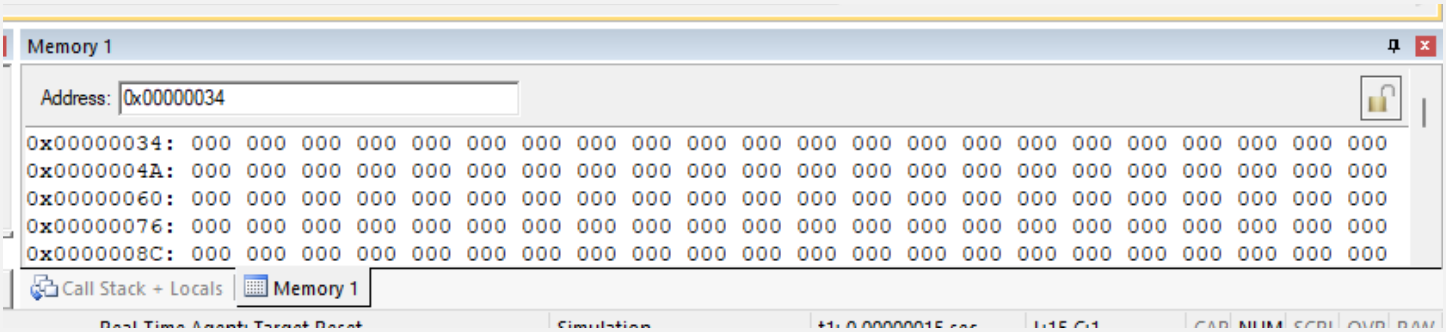
->

Source Code:

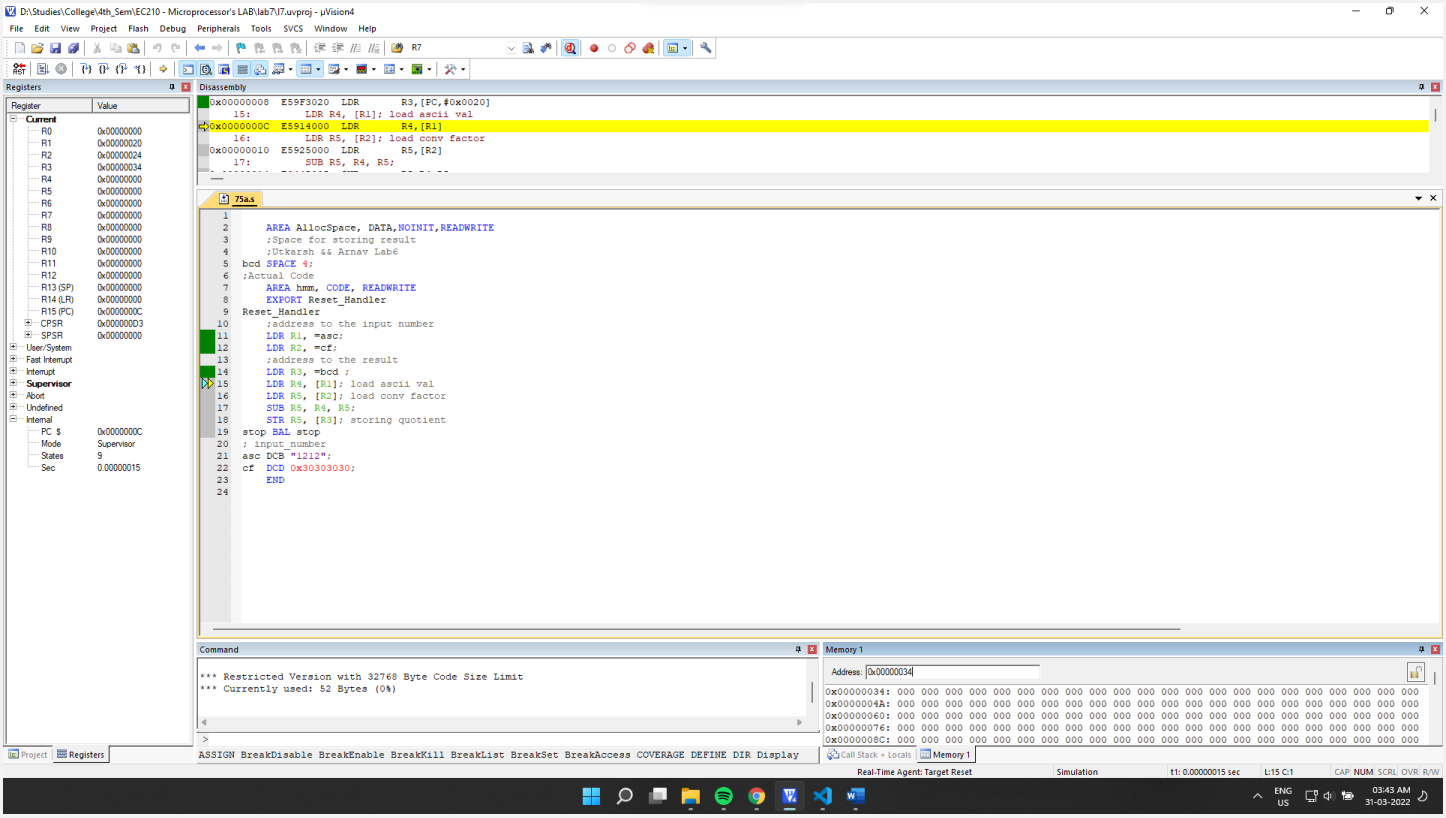
```
    AREA AllocSpace, DATA,NOINIT,READWRITE
    ;Space for storing result
    ;Utkarsh && Arnav Lab6
bcd SPACE 4;
;Actual Code
    AREA hmm, CODE, READWRITE
    EXPORT Reset_Handler
Reset_Handler
    ;address to the input number
    LDR R1, =asc;
    LDR R2, =cf;
    ;address to the result
    LDR R3, =bcd ;
    LDR R4, [R1]; load ascii val
    LDR R5, [R2]; load conv factor
    SUB R5, R4, R5;
    STR R5, [R3]; storing quotient
stop BAL stop
; input_number
asc DCB "1212";
cf  DCD 0x30303030;
    END
```

Debugging:

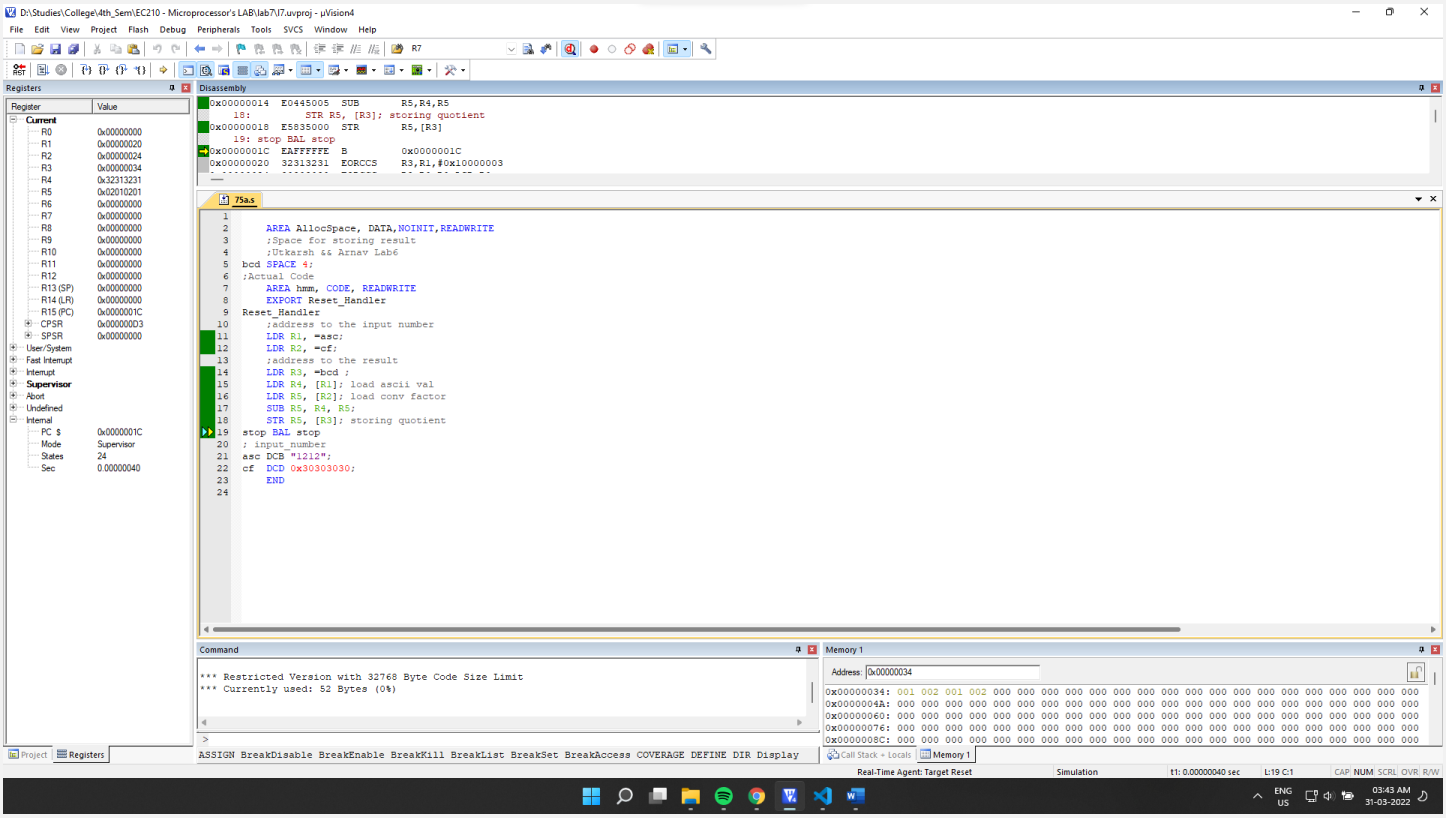
Initial Memory: (after getting the address through register)



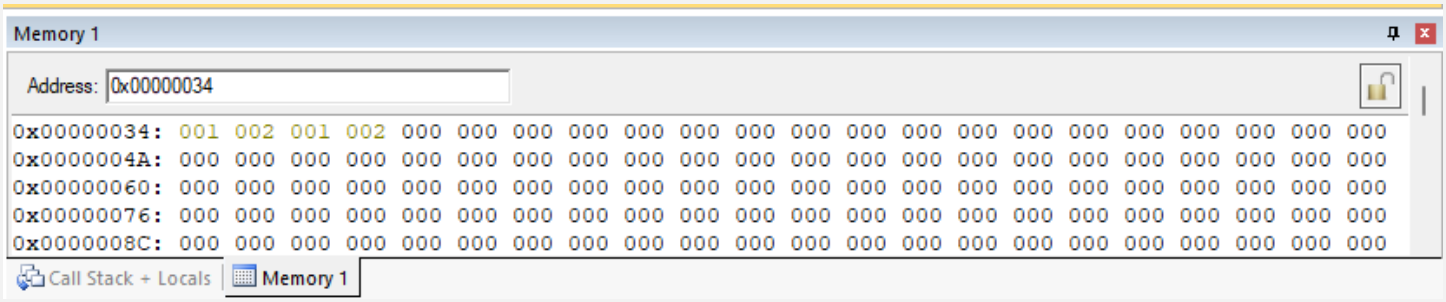
Setup:



Final Output:



Final Memory:



We can see that output in hex(decimal) matches our input (ASCII).

(b) ASCII to HX

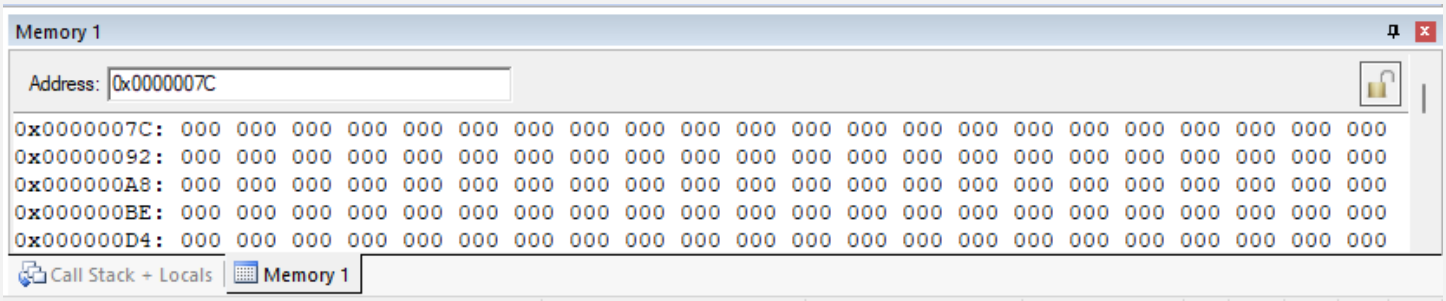
-> Source Code:

```
    AREA AllocSpace, DATA,NOINIT,READWRITE
    ;Space for storing result
    ;Utkarsh && Arnav Lab6
bcd SPACE 4;
;Actual Code
    AREA hmm, CODE, READWRITE
    EXPORT Reset_Handler
Reset_Handler
```

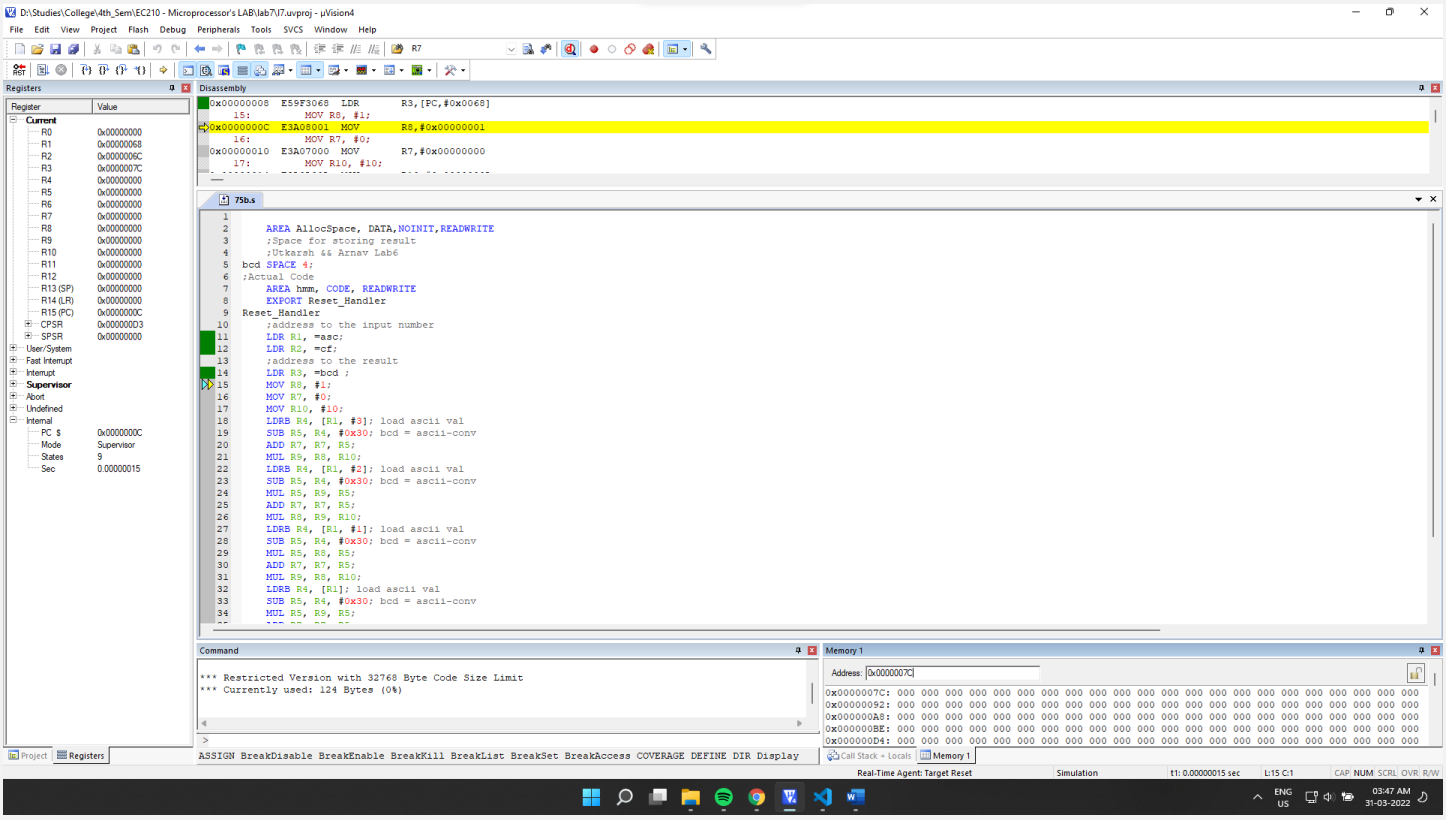
```
    ;address to the input number
    LDR R1, =asc;
    LDR R2, =cf;
    ;address to the result
    LDR R3, =bcd ;
    MOV R8, #1;
    MOV R7, #0;
    MOV R10, #10;
    LDRB R4, [R1, #3]; load ascii val
    SUB R5, R4, #0x30; bcd = ascii-conv
    ADD R7, R7, R5;
    MUL R9, R8, R10;
    LDRB R4, [R1, #2]; load ascii val
    SUB R5, R4, #0x30; bcd = ascii-conv
    MUL R5, R9, R5;
    ADD R7, R7, R5;
    MUL R8, R9, R10;
    LDRB R4, [R1, #1]; load ascii val
    SUB R5, R4, #0x30; bcd = ascii-conv
    MUL R5, R8, R5;
    ADD R7, R7, R5;
    MUL R9, R8, R10;
    LDRB R4, [R1]; load ascii val
    SUB R5, R4, #0x30; bcd = ascii-conv
    MUL R5, R9, R5;
    ADD R7, R7, R5;
    STR R7, [R3]; storing quotient
stop BAL stop
; input_number
asc DCB "1212";
cf  DCD 0x30303030;
    END
```

Debugging:

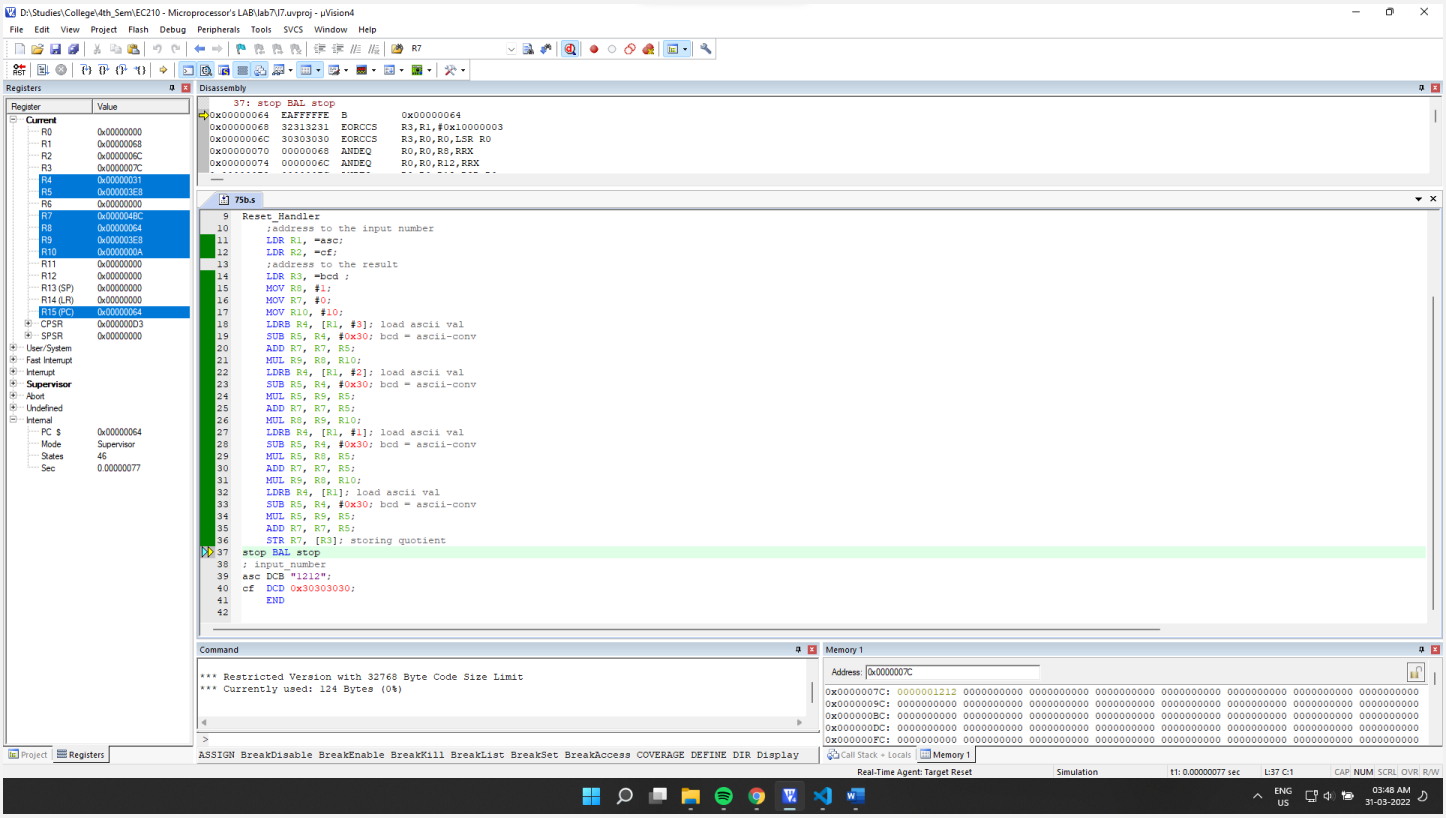
Initial Memory: (after getting the address through register)



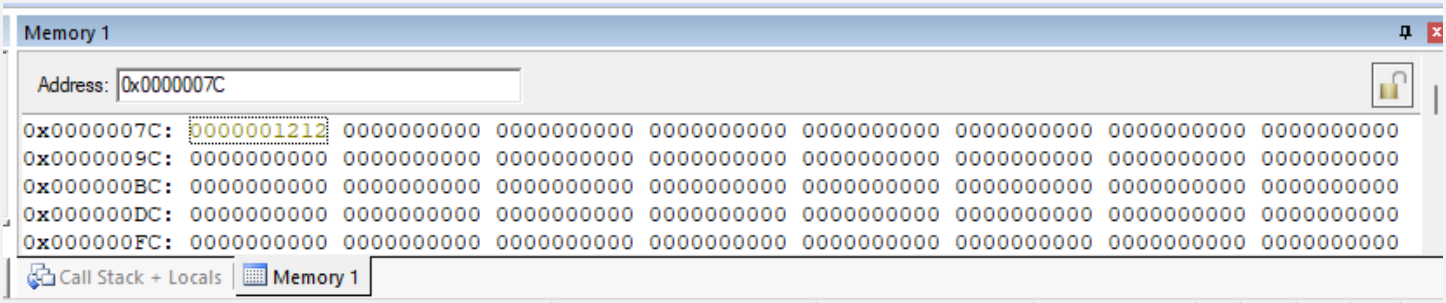
Setup:



Final Output:



Final Memory:



We can see that for the given input “1212” we got the proper hex value in the output.

(c) HX to ASCII

->

Source Code:

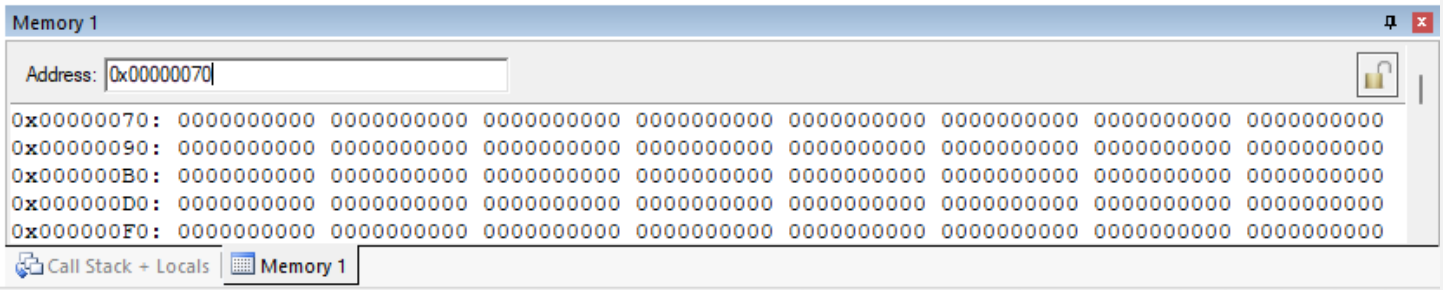
```
    AREA AllocSpace, DATA,NOINIT,READWRITE
    ;Space for result
array SPACE 1024;
;Actual Code
    AREA hmm, CODE, READWRITE
    EXPORT Reset_Handler
```

```
Reset_Handler
    ;address to the input number
    LDR R1, =inputnumber ;
    ;address for space used in operation
    LDR R2, =array;
    MOV R12, R2;
    ; load the  input number from memory
    LDR R4, [R1];
    LDRB R9, [R2];
    ADD R2 ,#3;
    ; Getting the last bit
    MOV R5, R4; R5 = R4
    MOV R6, #0;
    MOV R7, #0; for storing no of nos.
    ;dividing and finding nth digit.
    ;division by the use of subtracting
    ; until a remainder is found.
    ; where remainder < 10
div SUB R5, R5, #10; subtracting by 10
    CMP R5, #10; checking if remainder < 10
    ;incrementing iterator to store quotient
    ADD R6, R6, #1;
    ; if remainder >=10 then loop to sub further.
    BPL div
    ADD R7, #1; incrementing nos.
    ADD R5, R5, #0x30;
    STRB R5, [R2], #-1; storing digits
    ;comparing quotient and 10.
    CMP R6, #10;
    ;if quotient >10 then store quotient in remainder
    MOVPL R5, R6;
    ; && reset quotient
    MOVPL R6, #0;
    ; && loop again
    BPL div;
    ; check if quotient is zero
    CMP R6, #0;
    ; increment no of digits counter if no
    ADDNE R7, #1;
    ; &&  store it in R2 if no.
    ADD R6, R6, #0x30;
    STRBNE R6, [R2]; storing last digit
    ;
```

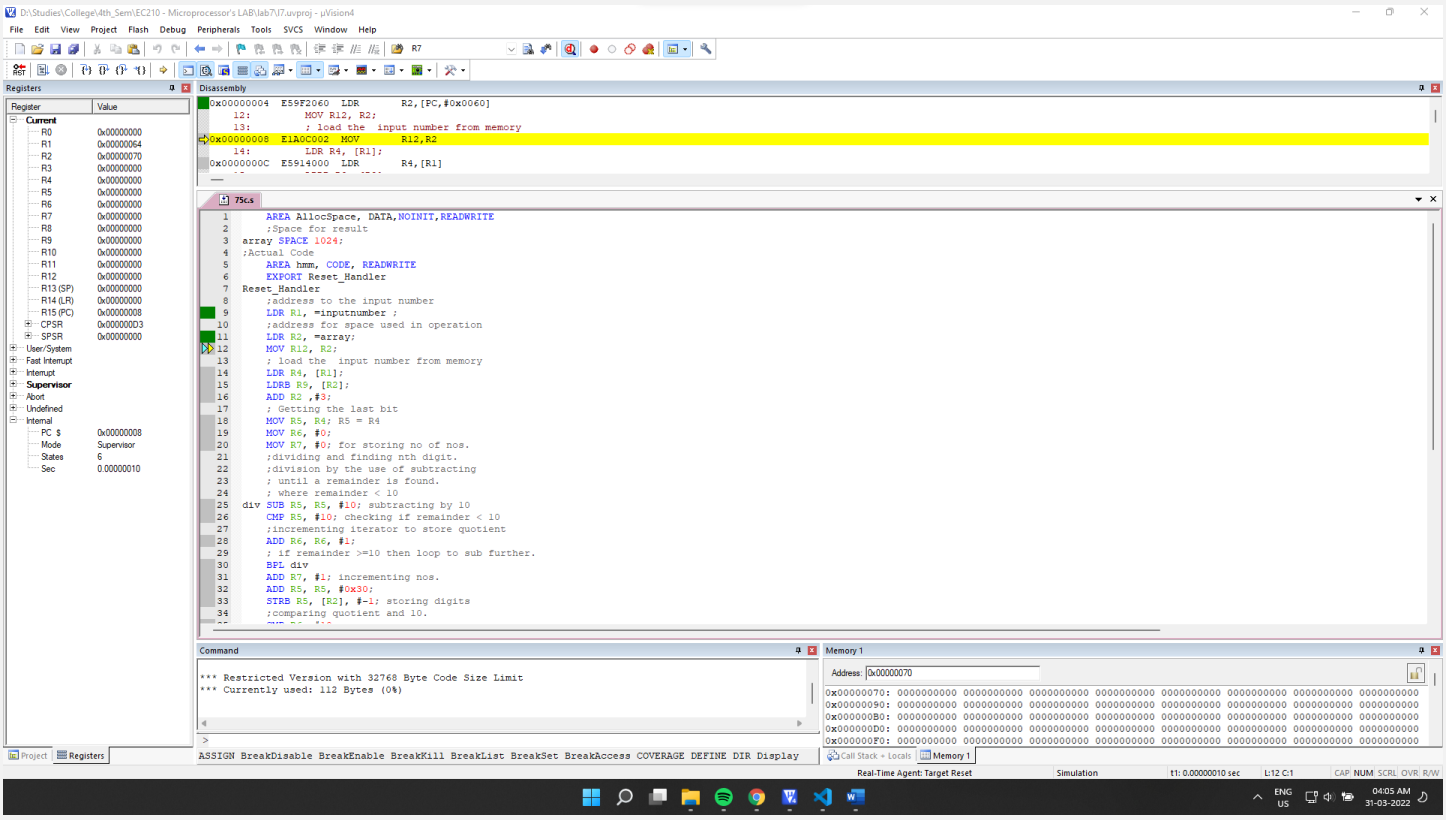
```
stop BAL stop
; input_number
inputnumber DCD 1425;
    END
```

Debugging:

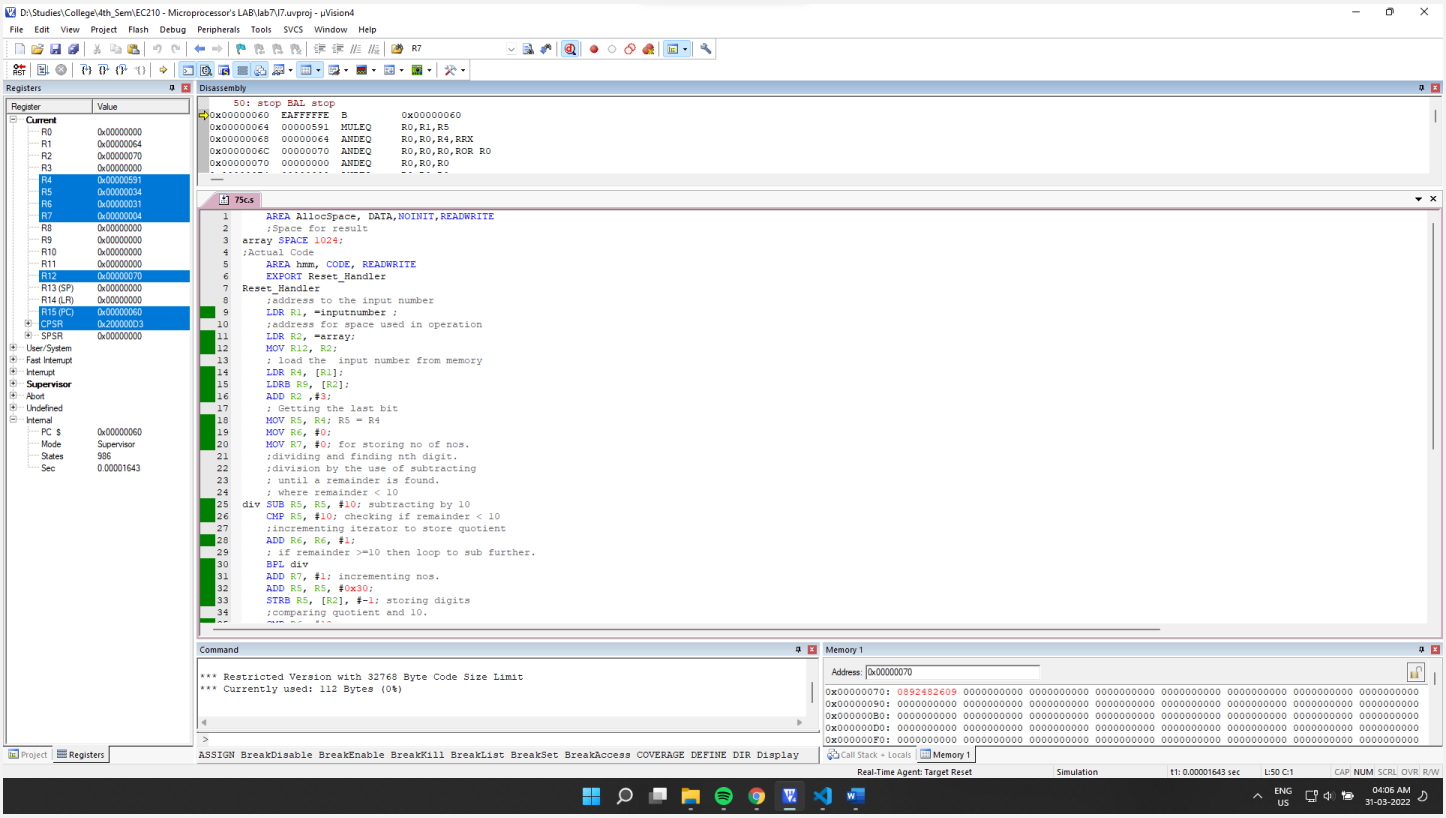
Initial Memory: (after getting the address through register)



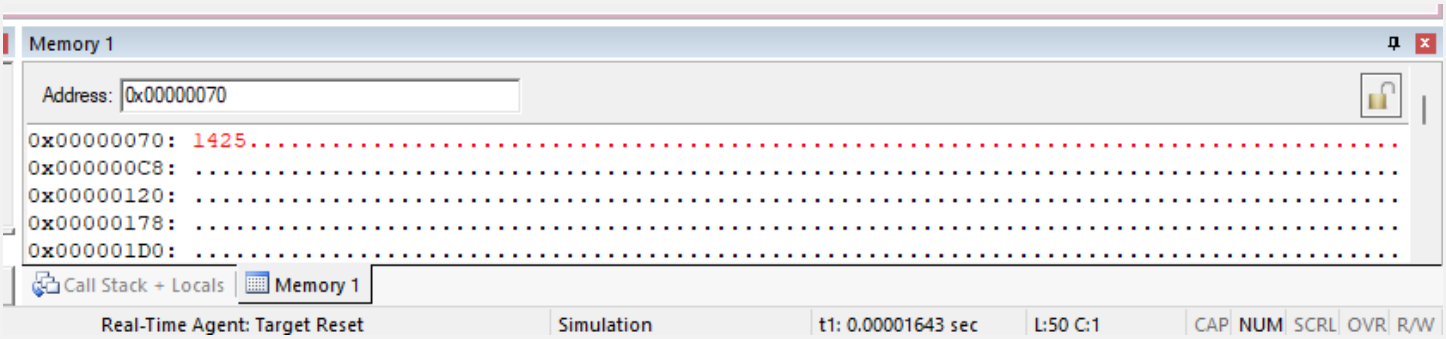
Setup:



Final Output:



Final Memory: (in ascii mode)



We can see that our output matches the expected result for the input 1425.

(d) BCD to ASCII

->

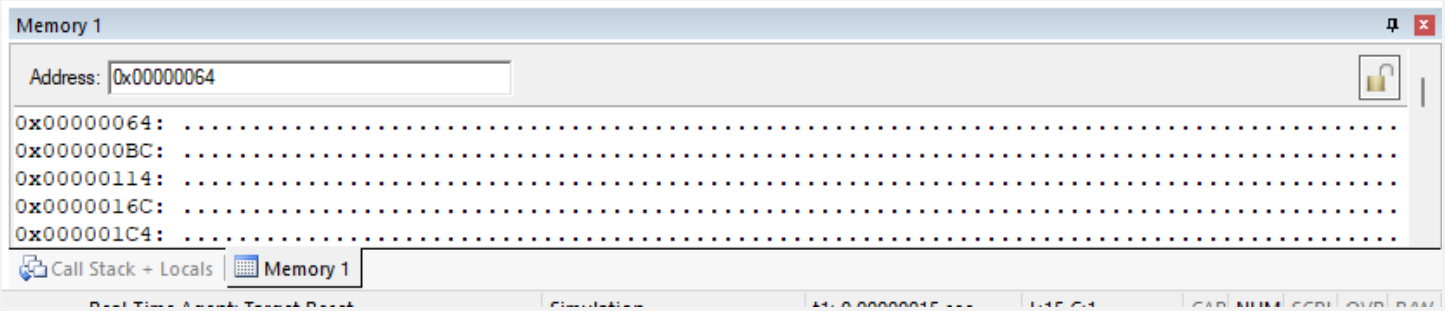
Source Code:

```
    AREA AllocSpace, DATA,NOINIT,READWRITE
    ;Space for storing result
    ;Utkarsh && Arnav Lab6
asc SPACE 4;
;Actual Code
```

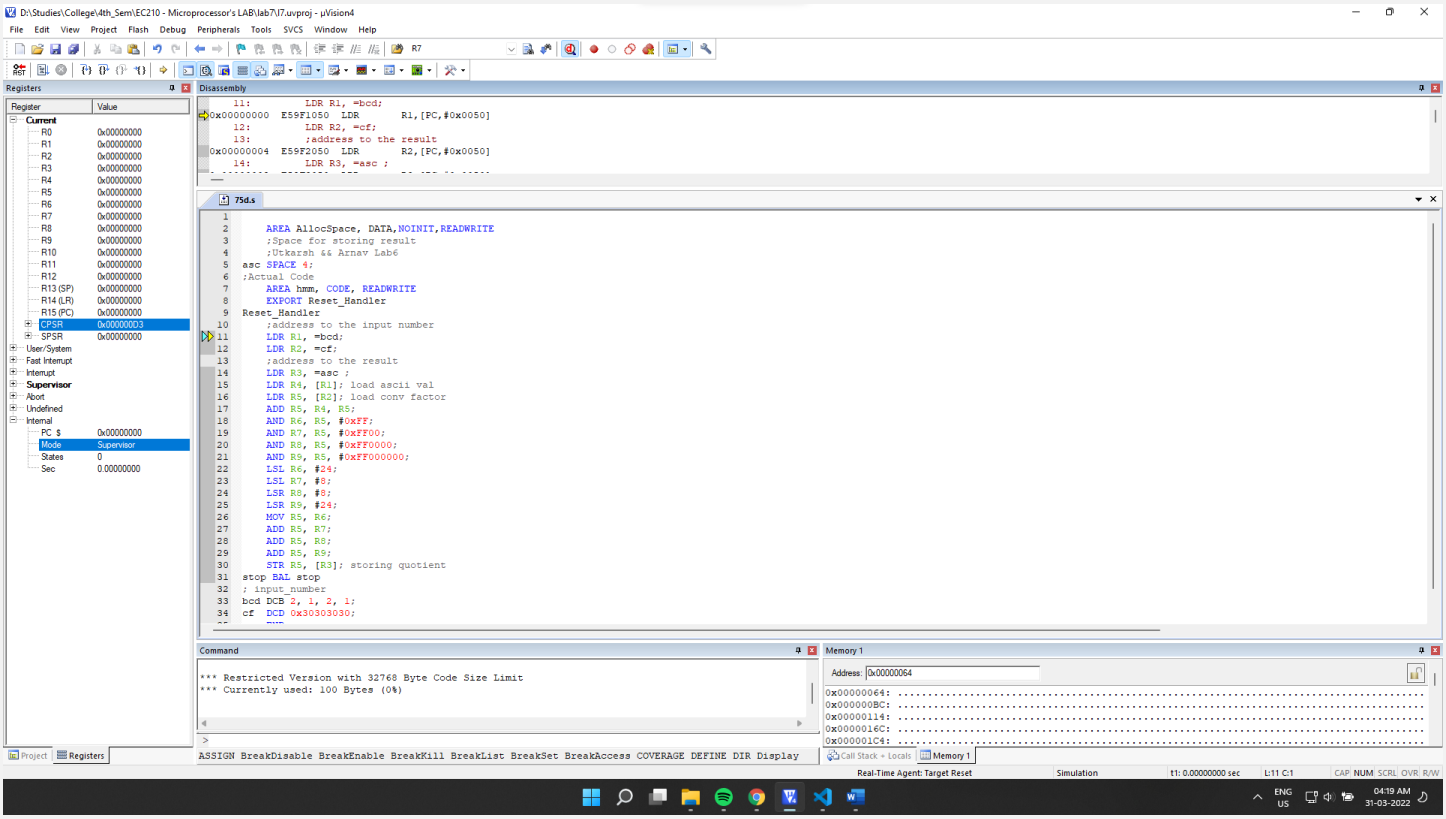
```
    AREA hmm, CODE, READWRITE
    EXPORT Reset_Handler
Reset_Handler
    ;address to the input number
    LDR R1, =bcd;
    LDR R2, =cf;
    ;address to the result
    LDR R3, =asc ;
    LDR R4, [R1]; load ascii val
    LDR R5, [R2]; load conv factor
    ADD R5, R4, R5;
    AND R6, R5, #0xFF;
    AND R7, R5, #0xFF00;
    AND R8, R5, #0xFF0000;
    AND R9, R5, #0xFF000000;
    LSL R6, #24; shifting towards other side as
    LSL R7, #8; required for ascii string
    LSR R8, #8;
    LSR R9, #24;
    MOV R5, R6;
    ADD R5, R7;
    ADD R5, R8;
    ADD R5, R9;
    STR R5, [R3]; storing quotient
stop BAL stop
; input_number
bcd DCB 2, 1, 2, 1;
cf  DCD 0x30303030;
    END
```

Debugging:

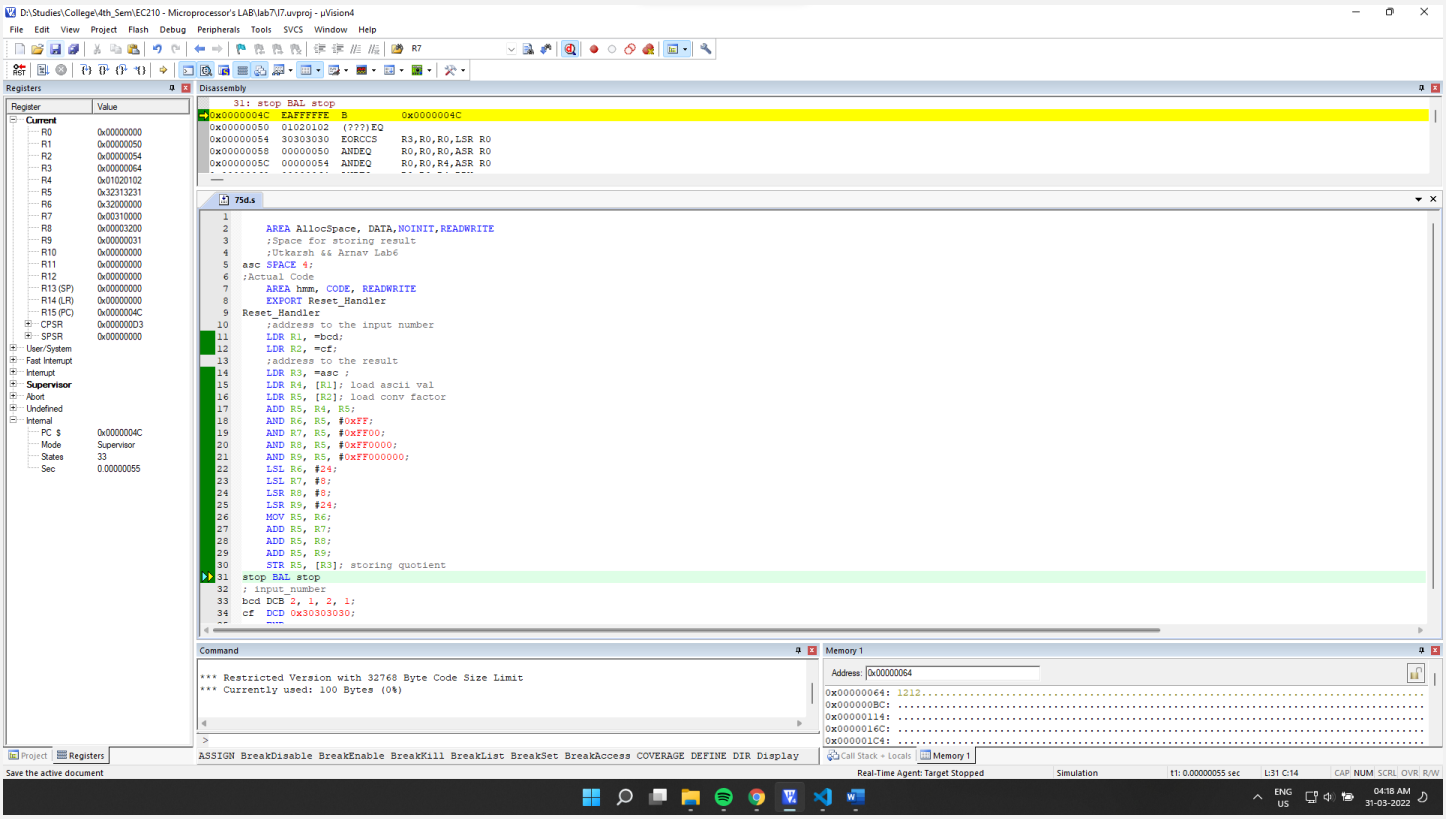
Initial Memory: (after getting the address through register)



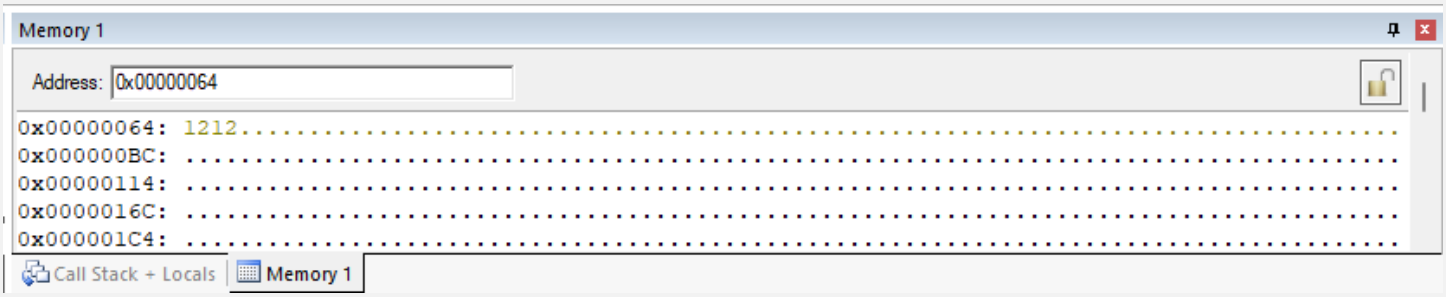
Setup:



Final Output:



Final Memory:


Memory 1
Address: 0x00000064
0x00000064: 1212
0x000000BC:
0x00000114:
0x0000016C:
0x000001C4:
Call Stack + Locals
Memory 1