EEEN 3449
Microprocessor Systems

Bit Testing

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I. INTRODUCTION

1.1 Purpose

The purpose of this experiment is explore the various ways of checking and counting individuals bits using the Assembly language.

1.2 Problem

Rotate and branching instructions were used to achieve the desired results in program A (Appendix A). A 2-byte number was rotated to the right a total of 16 times (iterating over each bit). Each iteration, the value of the carry flag (C) was checked to determine if there was a 1 that was rotated off. If C = 1, a counter was incremented. At the end of the program, the value of the counter was the number of 1s in the number.

Program B determined if each number in an array was divisible by 4. If it was, the number was moved to a new location. Else, it was moved to a different location. A mask branch instruction was used to determine the divisibility of numbers. For each iteration, the number was compared to $03 (binary: 0000 0011) to determine if the least two significant bits were set.

Program C determined if each number in array was divisible by 3. If it was, the number was moved to a new location. Else, it was moved to a different location. Instead of mask branch instruction, a division instruction was used. Each iteration, the number was divided by 3, and then the remainder was checked.

1.3 Scope

The scope of this experiment is limited to the HCS12 microcontroller. Several instructions will be used from the HCS12 instruction set.

II. TEST AND EVALUATION

2.1 Apparatus

The equipment used in this test includes: Dragon12-Junior development board, USB power cord, and laptop PC with AsmIDE.

2.2 Procedure

1. The development board was connected to the computer.
2. The COM port number was determined under Device Manager on PC. AsmIDE was launched. Under View -> Options -> COM Port, the COM port was set to the device's number. The Terminal Window was enabled. Under Set COM Options, the default values were restored.
3. Program A was opened, and then assembled. After no errors were recorded, program A was downloaded into the development board, by typing `load` in the Terminal Window in AsmIDE, then downloading the program.
4. `g 2000` was typed to execute the program. At the end of the program, `md 1505` was typed to confirm that the counter (stored at $1505) was correct.
5. Program B was opened, and then assembled. After no errors were recorded, program B was downloaded into the development board.
6. `g 2000` was typed to execute the program. At the end of the program, `md 1500` was typed to confirm that it contained all the numbers divisible by 4. `md 1520` was typed to confirm that it contained all the numbers not divisible by 4.

7. Program C was opened, and then assembled. After no errors were recorded, program C was downloaded into the development board.
8. `g 2000` was typed to execute the program. At the end of the program, `md 1500` was typed to confirm that it contained all the numbers divisible by 3. `md 1520` was typed to confirm that it contained all the numbers not divisible by 3.

III. RESULTS

3.1 Data

Table 1 displays the final result of program A after execution. $1505 contains the 1's counter.

Table 1: Final Result of Program A

ADDRESS	CONTENT
$1500	12
$1501	34
$1502	CF
$1503	23
$1504	79
$1505	05

Table 2 displays the final result of program B after execution. $1500 contains the numbers divisible by 4, $1540 contains the numbers not divisible by 4.

Table 2: Final Result of Program B

ADDRESS	CONTENT	ADDRESS	CONTENT	ADDRESS	CONTENT
$1500	1C	$1510	DE	$1520	01
$1501	4C	$1511	45	$1521	03
$1502	14	$1512	AA	$1522	05
$1503	40	$1513	58	$1523	06
$1504	79	$1514	5B	$1524	13
$1505	05	$1515	E6	$1525	29
$1506	59	$1516	C3	$1526	35
$1507	25	$1517	01	$1527	0D
$1508	BB	$1518	42	$1528	2A
$1509	93	$1519	10	$1529	0E
$150A	94	$151A	8D	$152A	36
$150B	00	$151B	8B	$152B	4A
$150C	89	$151C	94	$152C	1D
$150D	43	$151D	BC	$152D	21
$150E	CB	$151E	18	$152E	29
$150F	D3	$151F	90	$152F	2D

Table 3 displays the final result of program c after execution. $1500 contains the numbers divisible by 3, $1540 contains the numbers not divisible by 3.

Table 3: Final Result of Program C

ADDRESS	CONTENT	ADDRESS	CONTENT	ADDRESS	CONTENT
$1500	1C	$1510	DE	$1520	01
$1501	4C	$1511	45	$1521	03
$1502	14	$1512	AA	$1522	05
$1503	40	$1513	58	$1523	06
$1504	79	$1514	5B	$1524	13
$1505	05	$1515	E6	$1525	29
$1506	59	$1516	C3	$1526	35
$1507	25	$1517	01	$1527	0D
$1508	BB	$1518	42	$1528	2A
$1509	93	$1519	10	$1529	0E
$150A	94	$151A	8D	$152A	36
$150B	00	$151B	8B	$152B	4A
$150C	89	$151C	94	$152C	1D
$150D	43	$151D	BC	$152D	21
$150E	CB	$151E	18	$152E	29
$150F	D3	$151F	90	$152F	2D

3.2 Analysis

Figure 4: Flowchart of Program A

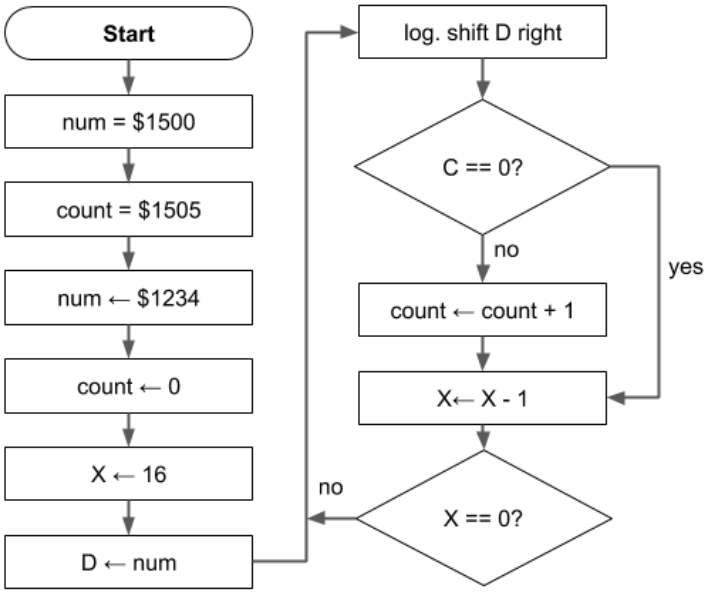


Figure 5: Flowchart of Program B

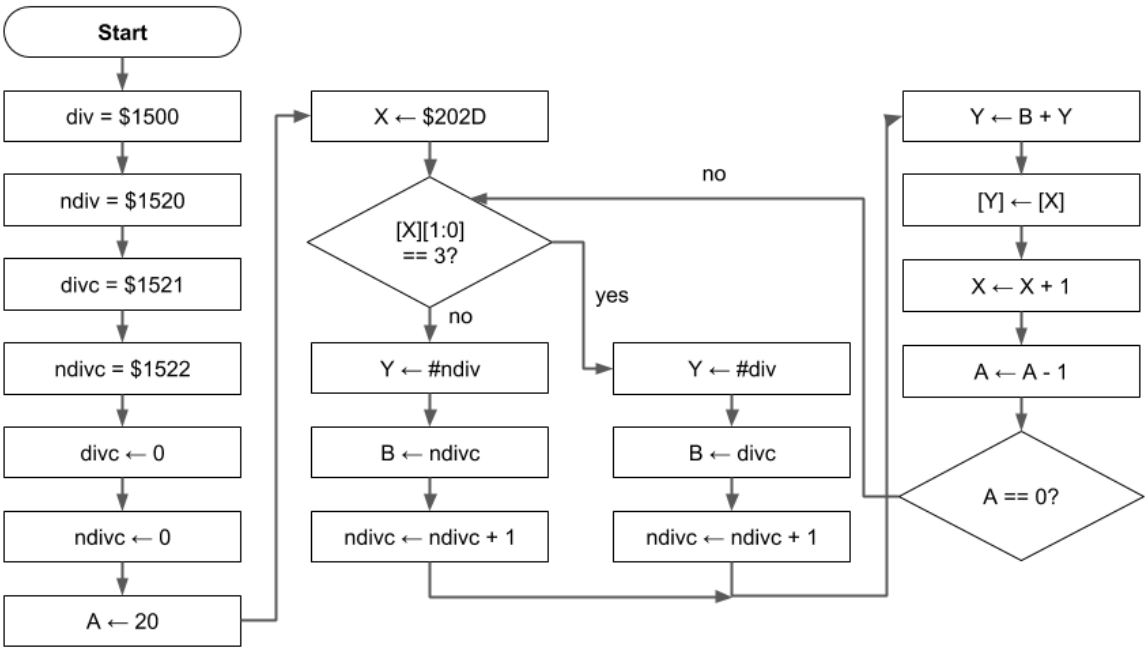
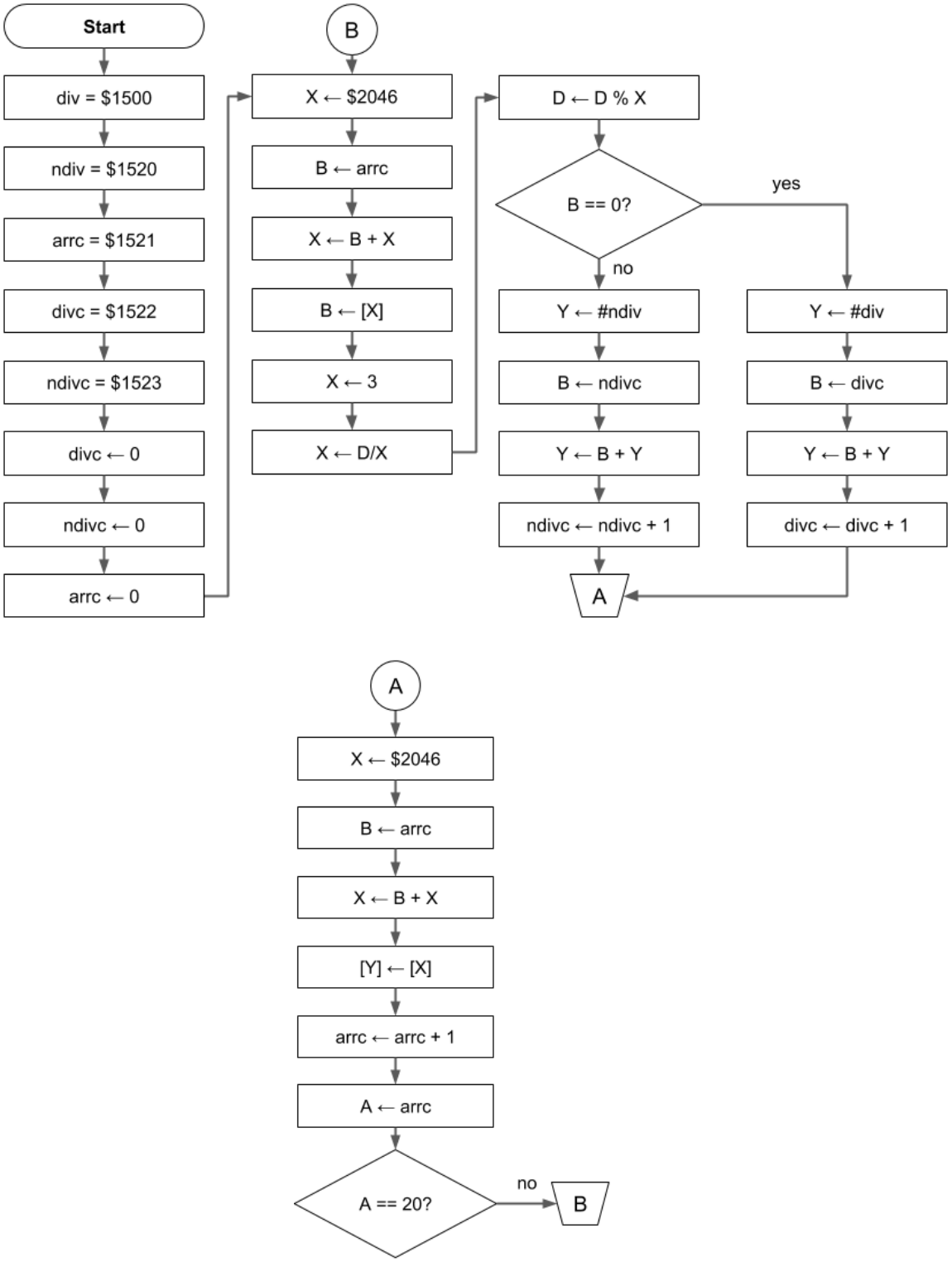


Figure 6: Flowchart of Program C



III. CONCLUSION

4.1 Assessment

This experiment served as an introduction to bit checking/counting. In part A, the rotate instruction was used to determine the number of 1s in a generic 2-byte number. In part B, a mask was used to determine if a generic number was divisible by 4. In part C, the division instruction was used to determine if a generic number was divisible by 3.

APPENDIX A

ASSEMBLY PROGRAM A

```
N       equ     16
        org     $1500
num     rmb     2
        org     $1505
count   rmb     1       ; 1s count
        org     $2000   ; program start
        movw    #$1234,$1500
        clr     count   ; count = 0
        ldx     #N      ; initialize loop counter to 16
        ldd     num     ; D = $1500
loop    lsrd            ; logical right shift D
        bcc     zero    ; branch to zero if carry flag = 0
        inc     count   ; increment 1s counter
zero    dbne    X, loop ; decrement X, branch if X == 0
        swi
        end
```

APPENDIX B

ASSEMBLY PROGRAM B

```
N       equ     20
        org     $1500
div     rmb     $20             ; 32 bytes for divisible-by-4 array
ndiv    rmb     $20             ; 32 bytes for not-divisible-by-4 array
divc    rmb     1               ; 1 byte for divisible counter
ndivc   rmb     1               ; 1 byte for non-divisible counter
        org     $2000
        movw    #0000, divc     ; clear both array counters
        ldaa    #N              ; A = array size
        ldx     #array          ; load address of main array into X
loop    brclr   0,X,$03,isdiv   ; branch if equal to mask
        ldy     #ndiv           ; Y = non-divisible array address
        ldab    ndivc           ; B = non-divisible array counter
        inc     ndivc           ; increment non-divisible counter
        bra     done            ; skip over true block
isdiv   ldy     #div            ; load address of divisible array to Y
        ldab    divc            ; load counter of divisible array to B
        inc     divc            ; increment divisible counter
done    aby                     ; Y = Y + B
        movb    1,X+,0,Y        ; move number, increment X
        dbne    A, loop         ; decrement A, branch to loop if A != 0
        swi
array   db      1, 3, 5, 6, 19, 41, 53, 28, 13, 42, 76, 14, 20, 54, 64,
74, 29, 33, 41, 45
        end
```

APPENDIX C

ASSEMBLY PROGRAM C

```
N       equ     20      ; array size
qnt     equ     3       ; divisor
        org     $1500
div     rmb     $20     ; reserve 32 bytes for divisible-by-3 array
ndiv    rmb     $20     ; reserve 32 bytes for not-divisible-by-3 array
arrc    rmb     1       ; reserve 1 byte for main array counter
divc    rmb     1       ; reserve 1 byte for divisible counter
ndivc   rmb     1       ; reserve 1 byte for non-divisible counter
        org     $2000
        fill    #00, 3  ; clear array counters
loop    ldx     #array  ; load pointer to main array into X
        ldab    arrc    ; B = array counter
        abx             ; B = B + X
        clra            ; A = 0
        ldab    0,X     ; B = m[X]
        ldx     #qnt    ; X = 3
        idiv            ; X = D/X, D = D % X
        cmpb    #0      ; compare least significant byte in D to 0
        beq     isdiv   ; if remainder == 0, goto isdiv branch
        ldy     #ndiv   ; load pointer to non-divisible array into Y
        ldab    ndivc   ; load non-divisible counter into B
        aby             ; Y = B + Y
        inc     ndivc   ; increment non-divisible counter
        bra     done    ; branch to done, skip over true block
isdiv   ldy     #div    ; load pointer to divisible array into Y
        ldab    divc    ; load divisible counter into B
        aby             ; Y = B + Y
        inc     divc    ; increment divisible counter
done    ldx     #array  ; load pointer to main array into X again
        ldab    arrc    ; load main array counter into B
        abx             ; X = B + X
        movb    0,X,0,Y ; move current element to designated array
        inc     arrc    ; increment main array pointer
        ldaa    arrc    ; A = main array pointer
        cmpa    #N      ; compare A to array size
        bne     loop    ; loop if A < size
        swi
array   db      1, 3, 5, 6, 19, 41, 53, 28, 13, 42, 76, 14, 20, 54, 64,
74, 29, 33, 41, 45
        end
```