- **An Example of Using the Stack**
- **Introduction to Programming the MC9S12 in C**
    - An example of using the stack
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## Examples of Using the Stack

Consider the following:

```
2000                        org   $2000
2000 cf 20 00               lds   #$2000
2003 ce 01 23               ldx   #$0123
2006 cc ab cd               ldd   #$abcd
2009 34                     pshx
200a 36                     psha
200b 37                     pshb
200c 07 04                  bsr   delay
200e 33                     pulb
200f 32                     pula
2010 30                     pulx
2011 3f                     swi

2012 34         delay:      pshx
2013 ce 03 e8               ldx    #1000
2016 04 35 fd  loop:        dbne  x,loop
2019 30                     pulx
201a 3d                     rts
```

The following does not work; the RTS goes to the wrong place

```
2000                        org   $2000
2000 cf 20 00               lds   #$2000
2003 ce 01 23               ldx   #$0123
2006 cc ab cd               ldd   #$abcd
2009 34                     pshx
200a 36                     psha
200b 37                     pshb
200c 07 04                  bsr   delay
200e 33                     pulb
200f 32                     pula
2010 30                     pulx
2011 3f                     swi

2012 34          delay:     pshx
2013 ce 03 e8               ldx   #1000
2016 04 35 fd loop:         dbne x,loop
2019 3d                     rts
```

## Using Registers in Assembly Language

• The DP256 version of the MC9S12 has lots of hardware registers

• To use a register, you can use something like the following:

**PORTB equ $0001**

• It is not practical to memorize the addresses of all the registers

• Better practice: Use a file which has all the register names with their addresses

**#include "hcs12.inc"**

• Here is some of hcs12.inc

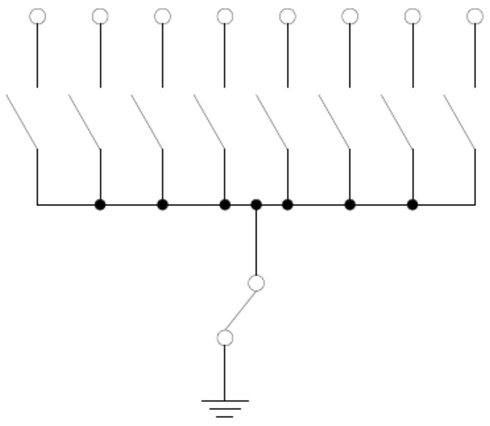
```
;
***********************************************************************
*
; Prepared by Dr. Han-Way Huang
; Date: 12/31/2004
; HC12SDP256 I/O register locations
; HCS12 peripheral bits definitions
; D-Bug12 I/O functions calling address
; D-Bug12 SRAM interrupt vector table
; Flash and EEPROM commands
;
***********************************************************************
*

PORTA           equ     0       ; port a = address lines a8 - a15
PTA             equ     0       ; alternate name for PORTA
PORTB           equ     1       ; port b = address lines a0 - a7
PTB             equ     1       ; alternate name for PORTB
DDRA            equ     2       ; port a direction register
DDRB            equ     3       ; port a direction register
```

## Using DIP switches to get data into the MC9S12

• DIP switches make or break a connection (usually to ground)

## DIP Switches on Breadboard



• To use DIP switches, connect one end of each switch to a resistor

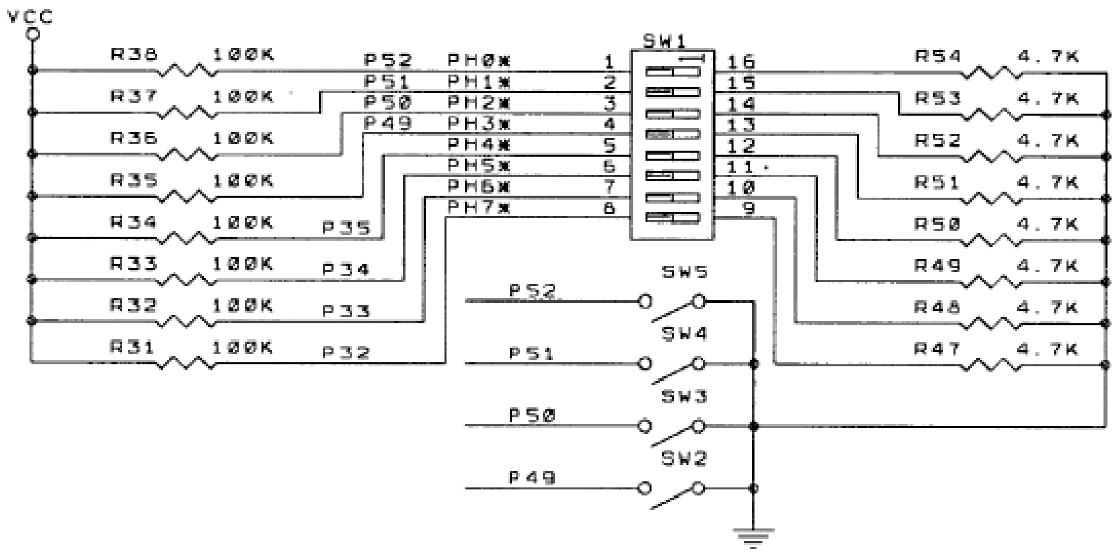
• Connect the other end of the resistor to +5 V

• Connect the junction of the DIP switch and the resistor to an input port on the MC9S12

• The Dragon12-Plus has eight dip switches connected to Port H (PTH)

• The four least significant bits of PTH are also connected to push-button switches.

- If you want to use the push-button switches, make sure the DIP switches are in the OFF position.



• When the switch is open, the input port sees a logic 1 (+5 V)

• When the switch is closed, the input sees a logic 0 (0.22 V)

## Looking at the state of a few input pins

• Want to look for a particular pattern on 4 input pins

– For example want to do something if pattern on PH3-PH0 is 0110

• Don't know or care what are on the other 4 pins (PH7-PH4)

• Here is the wrong way to do it:

```
ldaa    PTH
cmpa    #$06
beq     task
```

• If PH7-PH4 are anything other than 0000, you will not execute the task.

• You need to mask out the Don't Care bits before checking for the pattern on the bits you are interested in

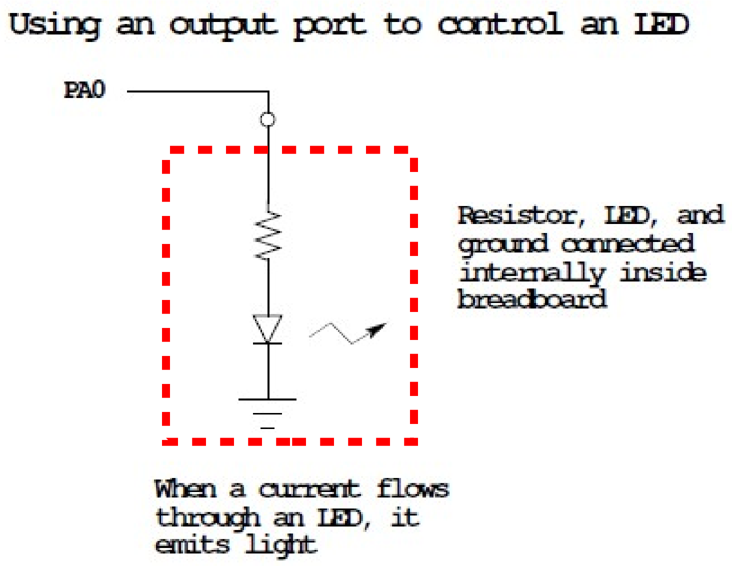
– To mask out don't care bits, AND the bits with a mask which has 0's in the don't care bits and 1's in the bits you want to look at.

```
ldaa    PTH
anda    #$0F
cmpa    #$06
beq     task
```

• Now, whatever pattern appears on PH7-4 is ignored

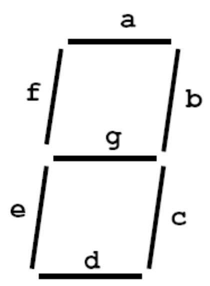
## Using an HC12 output port to control an LED

• Connect an output port from the HC12 to an LED.


Using an output port to control an LED
PA0
Resistor, LED, and ground connected internally inside breadboard
When a current flows through an LED, it emits light

## Making a pattern on a seven-segment LED

• Want to generate a particular pattern on a seven-segment LED:



• Determine a number (hex or binary) which will generate each element of the pattern

– For example, to display a 0, turn on segments a, b, c, d, e and f, or bits 0, 1, 2, 3, 4 and 5 of PTH. The binary pattern is 0011 1111, or $3f.

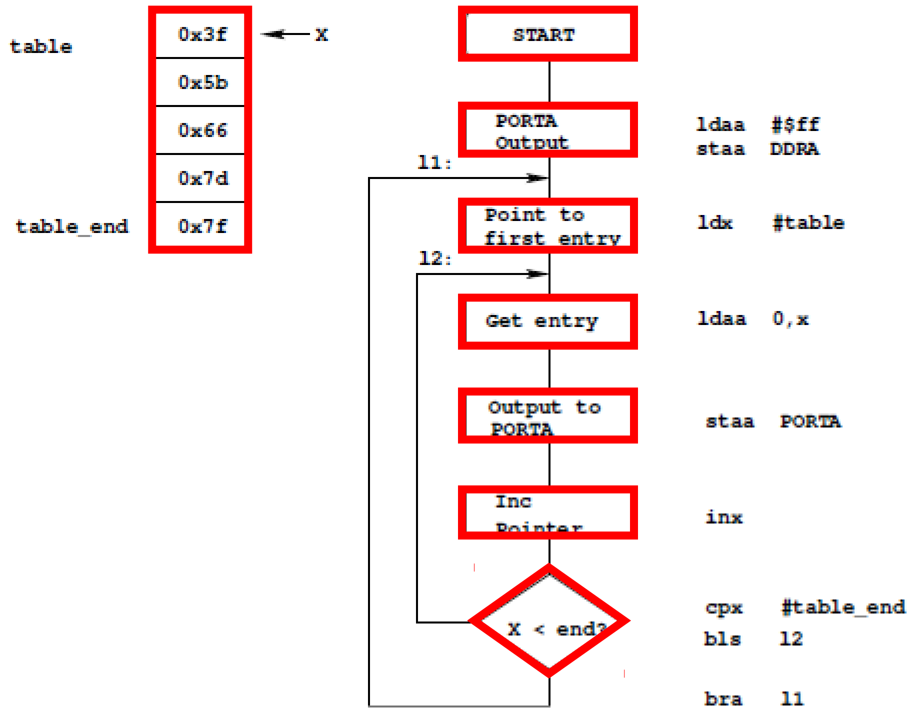
– To display 0 2 4 6 8, the hex numbers are $3f, $5b, $66, $7d, $7f.

• Put the numbers in a table

• Go through the table one by one to display the pattern

• When you get to the last element, repeat the loop

## Flowchart to display a pattern of lights on a set of LEDs



```
ldaa  #$ff
staa  DDRA

ldx   #table

ldaa  0,x

staa  PORTA

inx

cpx   #table_end
bls   l2

bra   l1
```

as12, an absolute assembler for Motorola MCU's, version 1.2h

```
; Program to display a pattern on a seven-segment LED display

                                  #include "hcs12.inc"
2000                              prog: equ $2000
1000                              data: equ $1000
2000                              stack: equ $2000

0005               table_len:     equ (table_end-table)

2000                              org prog
2000 cf 20 00                     lds #stack   ; initialize stack pointer
2003 86 ff                        ldaa #$ff    ; Make PORTB output
2005 5a 03                        staa DDRB    ; 0xFF -> DDRB
2007 ce 10 00             l1:     ldx #table   ; Start pointer at table
200a a6 00                l2:     ldaa 0,x     ; Get value
200c 5a 01                        staa PORTB ; Update LEDs
200e 07 08                        bsr delay    ; Wait a bit
2010 08                           inx          ; point to next
2011 8e 10 05                     cpx #table_end ; More to do?
2014 25 f4                        blo l2       ; Keep going through table
2016 20 ef                        bra l1       ; At end; reset pointer

2018 36            delay:         psha
2019 34                           pshx
201a 86 64                        ldaa         #100
201c ce 1f 40      loop2:         ldx          #8000
201f 04 35 fd      loop1:         dbne         x,loop1
2022 04 30 f7                     dbne         a,loop2
2025 30                           pulx
2026 32                           pula
2027 3d                           rts

1000                              org data
1000 3f            table:         dc.b $3f
1001 5b                           dc.b $5b
1002 66                           dc.b $66
1003 7d                           dc.b $7d
1004 7f                           dc.b $7F
1005               table_end:
```

## Putting a program into EEPROM on the Dragon12-Plus

• EEPROM from 0x400 to 0xFFF

• Program will stay in EEPROM memory even after power cycle

– Data will not stay in RAM memory (!)

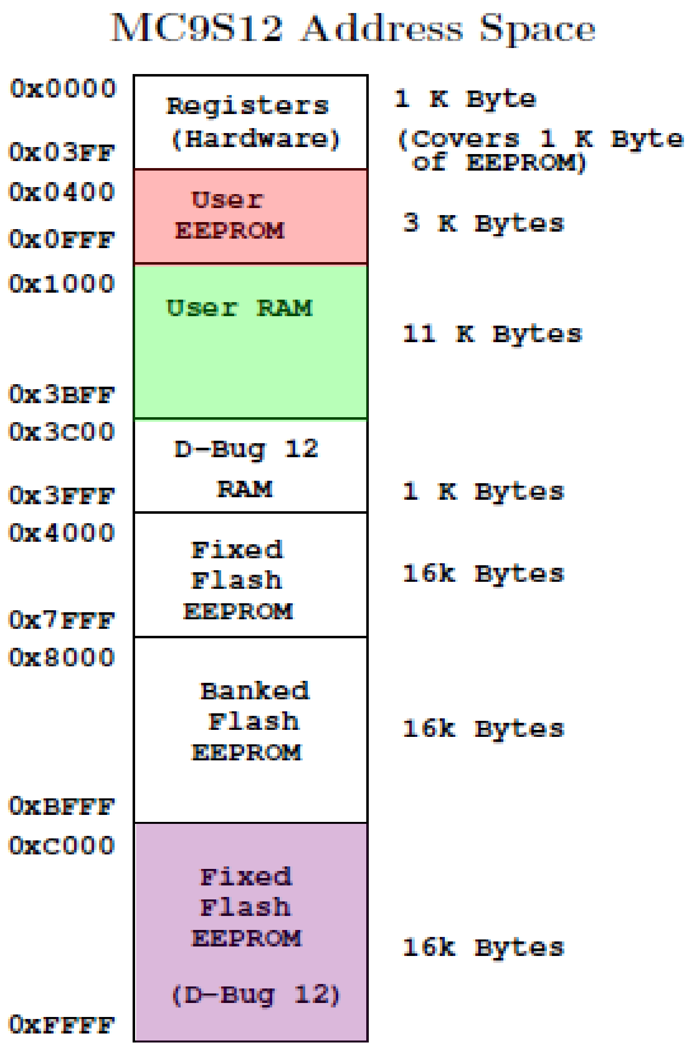
• If you put the above program into EEPROM, then cycle power, you will display a sequence of patterns on the seven-segment LED, but the pattern will be whatever junk happens to be in RAM.

• To make sure you retain your patterns, put the table in the text part of your program, not the data part.

• If you use a variable which needs to be stored in data, be sure you initialize that variable in your program and not by using dc.b.

• The Dragon12 board uses an 8 MHz clock. The MC9S12 has an internal phase-locked loop which can change the clock speed. DBug12 increases the clock speed from 8 MHz to 48 MHz.

• When you run a program from EEPROM, DBug12 does not run, so your program will run six times slower that it would using DBug12. The lab has instructions on how to increase the MC9S12 clock from 8 MHz to 48 MHz so your program will run with the same speed as under DBug12.



• Here is the above program with table put into EEPROM

• Also, we have included a variable *var* which we initialize to $aa in the program

– We don't use var in the program, but included it to show you how to use a RAM-based variable

```
#include        "hcs12.inc"
prog:           equu    $0400
data:           equ     $1000
stack:          equ     $2000
table_len:      equ      (table_end-table)

                org     prog
                lds     #stack          ; initialize stack pointer
                movb    #$aa,var        ; initialize var
                ldaa    #$ff            ; Make PORTB output
                staa    DDRB            ; 0xFF -> DDRB
l1:             ldx      #table         ; Start pointer at table
l2:             ldaa    0,x             ; Get value
                staa    PORTB           ; Update LEDs
                bsr     delay           ; Wait a bit
                inx                     ; point to next
                cpx     #table_end      ; More to do?
                blo     l2              ; Yes, keep going through table
                bra     l1              ; At end; reset pointer

delay:          psha
                pshx
                ldaa    #100
loop2:          ldx     #8000
loop1:          dbne    x,loop1
                dbne    a,loop2
                pulx
                pula
                rts

table:          dc.b $3f
                dc.b $5b
                dc.b $66
                dc.b $7d
                dc.b $7F
table_end:

                org data
var:            ds.b 1                  ; Reserve one byte for var
```

# Programming the MC9S12 in C

• A comparison of some assembly language and C constructs

| Assembly | C |
|---|---|
| ; Use a name instead of a num | /* Use a name instead of a num */ |
| COUNT: EQU 5 | #define COUNT 5 |
| ;------------------------------------------ | /*------------------------------*/ |
| ;start a program | /* To start a program */ |
| org $1000 | main() |
| lds #0x3C00 | { |
| | } |
| ;------------------------------------------ | /*------------------------------*/ |

• Note that in C, the starting location of the program is defined when you compile the program, not in the program itself.

• Note that C always uses the stack, so C automatically loads the stack pointer for you.

| Assembly | C |
|---|---|
| ; allocate two bytes for | /* Allocate two bytes for |
| ; a signed number | * a signed number */ |
| org $2000 | |
| i: ds.w 1 | int i; |
| j: dc.w $1A00 | int j = 0x1a00; |

| Assembly | C |
|---|---|
| `;-----------------------------------------`<br>`; allocate two bytes for`<br>`; an unsigned number`<br><br>`i:      ds.w   1`<br>`j:      dc.w   $1A00` | `/*-----------------------------*/`<br>`/* Allocate two bytes for`<br>` * an unsigned number */`<br><br>` unsigned int i;`<br>` unsigned int j = 0x1a00;` |
| `; allocate one byte for`<br>`; a signed number`<br><br>`i:      ds.b   1`<br>`j:      dc.b   $1F`<br><br>`;-----------------------------------------`<br>`; Get a value from an address`<br>`; Put contents of address`<br>`; $E000 into variable i`<br><br>`i:      ds.b   1`<br><br>`        ldaa   $E000`<br>`        staa   i` | `/* Allocate one byte for */`<br>`/* a signed number */`<br><br>`signed char i;`<br>`signed char j = 0x1f;`<br><br>`/*-----------------------------*/`<br>`/* Get a value from an address */`<br>`/* Put contents of address */`<br>`/* 0xE000 into variable i */`<br><br>`unsigned char i;`<br><br>`i = * (unsigned char *) 0xE000;`<br><br>`/*-----------------------------------*/`<br>`/* Use a variable as a pointer`<br>`(address) */`<br><br>`unsigned char *ptr, i;`<br><br>`ptr = (unsigned char *) 0xE000;`<br>`i = *ptr;` |

• In C, the construct *(num) says to treat num as an address, and to work with the contents of that address.

• Because C does not know how many bytes from that address you want to work with, you need to tell C how many bytes you want to work with. You also have to tell C whether you want to treat the data as signed or unsigned.

- i = * (unsigned char *) 0xE000; tells C to take one byte from address 0xE000, treat it as unsigned, and store that value in variable i.

- j = * (int *) 0xE000; tells C to take two bytes from address 0xE000, treat it as signed, and store that value in variable j.

- * (char *) 0xE000 = 0xaa; tells C to write the number 0xaa to a single byte at addess 0xE000.

- * (int *) 0xE000 = 0xaa; tells C to write the number 0x00aa to two bytes starting at address 0xE000.

| Assembly | C |
|---|---|
| ;--------------------------------- | /*-----------------------------*/ |
| ; To call a subroutine | /* To call a function */ |
| ldaa i | sqrt(i); |
| jsr sqrt | |
| | |
| ;-------------------------------- | /*-----------------------------*/ |
| ; To return from a subroutine | /* To return from a function */ |
| ldaa j | return j; |
| rts | |
| | |
| ;-------------------------------- | /*-----------------------------*/ |
| ; Flow control | /* Flow control */ |
| blo | if (i < j) |
| blt | if (i < j) |
| | |
| bhs | if (i >= j) |
| bge | if (i >= j) |
| ;--------------------------------- | /*-----------------------------*/ |

• Here is a simple program written in C and assembly. It simply divides 16 by 2. It does the division in a function.

| Assembly | C |
|---|---|
| <pre>        org     $1000<br>i:      ds.b    1<br><br><br>        org     $2000<br>        lds     #$3C00<br>        ldaa    #16<br>        jsr     div<br>        staa    i<br>        swi<br><br>div:    asra<br>        rts</pre> | <pre>unsigned char i;<br><br><br>unsigned char div(unsigned char j);<br>main()<br> {<br>        i = div(16);<br> }<br><br><br>unsigned char div(unsigned char j)<br>{<br>        return j >> 1;<br>}</pre> |