Programming the Motorola MC68HC11 Microcontroller

CONTENTS:

COMMON PROGRAM INSTRUCTIONS WITH EXAMPLES

aba **Add register B to register A** *Similar commands are* `abx aby`

`aba` add the value in register B to the value in register A and store in register A

anda **Logical And with register A** *Similar command is* `andb` Differs from `bita` in that the contents of register A is changed

`anda #label` perform a logical AND between the value stored at memory location *label* and register A and store the result in register A

asr **Arithmetic Shift Right** *Similar commands are* `asra asrb asl asla aslb`

`asr` Preserves signed numbers by retaining the leading bit. Use `lsr` and related commands with unsigned numbers. A right shift divides by 2, a left shift multiplies by 2.

bcc **Branch if C-bit is clear** *Similar command is* `bcs` *(branch if C-bit set)*

`bcc` branches if the C-bit is clear. The C-bit indicates a carry or borrow.

bclr **Clear Bit(s)** *Similar command is* `bset`

`bclr #label $F0` this example zeros the first four bits of the value stored at memory location *label*. `$F0` is the *mask*, in binary it is 11110000; the 1's correspond to the bits that will be cleared.

beq **Branch on Equal or Zero, i.e. if CCR Z-bit is 1**

`cmpa #20` compares the value in register A to decimal 20 by subtracting 20 from A.

`beq label` if the last value in memory was a zero (checks the CCR Z-bit) then go to program location *label.*

`tsta` test the value in register A

`beq label` if the value in register A is zero (i.e. the Z-bit is set) then we branch to the memory location *label*.

bita **Logical And with register A** *Similar commands are* `bita, bitb` Differs from `anda` in that register A remains unchanged. The result affects only the CCR.

`bita #%10000000` this example checks bit 7 in register A and set the CCR accordingly. This could be follow with the beq or bne instruction to branch based on the result of the bit test. Another way to test bit 7 is to simply tsta and then branch based on the N-bit since bit 7 = 1 is characteristic of a signed negative number and will set the N-bit of the CCR.

ble **Branch if Lower or Equal** Compares **signed** numbers. *Similar commands:* `blt` (branch if lower), `bgt` (branch if greater than), `bge` (branch if greater or equal). See `bls` for comparable *unsigned* number commands with examples.

bls **Branch if Lower or Same** Compares **unsigned** numbers. *Similar commands:* `blo` (branch if lower), `bhi` (branch if higher), `bhs` (branch if higher or same). May not work properly if there is an overflow.

```
cba              first compare the value in register B to the value in register A  (A-B)
bls   label      branch to location label if A is less than or equal to B
```

```
ldd   Num1       16-Bit Version:  first load the value stored at Num1 into register D
cpd   #1000      compare the value in D to 1000
bls   label      branch to location label if D is less than or equal to 1000
```

bmi **Branch on Minus** *Similar command is* `bpl` *(branch on positive)*

```
tsta             test the value in register A
bmi   label      if the value in register A is negative (i.e. the N-bit is set) then we branch to
                 the memory location label.
```

bne **Branch if Not Equal or Zero** *Opposite of* `beq`

bra **Branch**

```
bra   label      go to program location label and continue execution (don't return).
```

brclr **Branch if Bit(s) Clear**

```
brclr label1 #%11100000 label2    go to program location label2 if the first three bits of
                                  the value stored at label1 are zeros (clear).
```

bsr **Branch to Subroutine**

```
bsr   label      go to the subroutine at program location label and return here when done
```

bvs **Branch if Overflow bit is set**

```
bvs   label      go to the program location label if the v bit is set in the CCR.  The V-bit
                 indicates a twos-complement overflow.
```

cba **Compare B to A** *Similar commands are* `cmpa cmpb cpd cpx cpy`; see example at `bls`

```
cba              compare the value in register B to the value in register A by subtraction (A-B)
                 and set the CCR accordingly.  If A=B then Z→1.  Can be used before beq,
                 ble, blt, bgt, bge, bls, blo, bhi, bhs, etc.
```

clr **Replace Contents with Zeros** *Similar commands are* `clra clrb`

```
clr   Ddrc       this example causes Port C to be an input port (all pins).  This would go
                 near the beginning of the program after the lds command.
clra             this example places zeros in register A.
```

cmpa **Compare to A** — *Similar commands are* `cba cmpb cpd cpx cpy`; see example at `bls`

`cmpa #$04` — this example compares the value in register A to $04 by subtracting $04 from register A. If the result is zero then they are equal and the CCR bit Z is set to 1. $04 is EOT or end of string. Often used before `beq.`

`cmpa #EOT` — this example compares the character in register A to the end of string character.

`cmpa #end-3` — "end" must be a constant, not a label. The subtraction of end-3 is performed and the value in register A is compared to the result.

`cmpa 0,x` — compare the value in register A to the value in the byte pointed to by register X.

Refer also to the ldaa command for discussion on the use of the # sign.

coma **Complement of A** — *Similar commands are* `com comb`

`coma` — complement the value in register A and store the result in register A.

dec **Decrement by 1** — *Similar commands are* `deca decb des dex dey`

`dec label` — decrement the value stored at memory location *label* by 1.

`deca` — decrement the value stored in register A by 1. (Inherent addressing)

`des` — decrement the stack pointer; may be used to **allocate** stack space

`dec 0,x` — decrement the value stored at the top of the stack

end **End Program**

`end` — last program instruction

eora **Exclusive OR with reg A** — *Similar command is* `eorb`

`eora label` — an exclusive OR is performed with the contents of register A and the value at address *label* with the result stored in register A.

equ **Equate a Label to a Value**

`label equ 3` — the assembler substitutes the value 3 wherever it sees *label* in the code. This does not use any memory space. The purpose is to facilitate code maintenance by permitting a single change of value here to result in multiple changes throughout the code wherever *label* appears. The line should be placed toward the beginning of the program or section of code before the first use of *label*.

fcb **Form Constant Byte** — see SUBROUTINE LIBRARIES

fcc **Form Constant Character String** — see SUBROUTINE LIBRARIES

fdb **Form Double Byte Constant**

`fdb main` — This particular example is common to all our programs. By appearing after the `org $FFFE` instruction near the end of the program, this code loads the starting address of the program (represented by the label *main*) into the last two bytes of ROM. The cpu looks in the last two bytes of ROM to obtain the address for the beginning of the program when power is applied or in the event of a reset.

`label fdb 5,8,465,17,89` — 5 is stored in a 2-byte block at mem location *label*, 8 is stored in a 2-byte block at location *label*+2, etc..

fdiv

Fractional Divide D/X — *Related commands are* `fdiv, mul`

`ldd #2`	2 is loaded into register D (numerator)
`ldx #3`	3 is loaded into register X (denominator)
`fdiv`	actually, the numerator is multiplied by 65536 before being divided by the denominator, quotient (43690) goes in register X, remainder (2) in register D, I think.

inc

Increment by 1 — *Similar commands are* `inca incb ins inx iny`

`inc label`	increment the value stored at memory location *label* by 1.
`inca`	increment the value stored in register A by 1. (Inherent addressing)
`ins`	increment the stack pointer; used to **deallocate** space on the stack

idiv

Integer Divide D/X — *Related commands are* `fdiv, mul`

`ldd #9`	9 is loaded into register D (numerator)
`ldx #4`	4 is loaded into register X (denominator)
`idiv`	division takes place, quotient (2) goes in register X, remainder (1) in register D

jmp

Jump to Another Location

`jmp label`	go to program location *label*. You can use this if you are not planning on returning to the current location.

jsr

Jump to Subroutine

`jsr InString`	go to a subroutine. This is used with the libraries because they are too far away to be accessed with the branch instructions which use relative addressing. Program execution returns to this point following the subroutine.
`jsr InitSCI`	this example initializes the serial port (SCIWin on our simulator) and appears once in the program right after *main*. `InitSCI` is in our subroutine library.

ldaa

Load Register A — *Similar commands are* `ldab ldd lds ldx ldy`

`ldd 10`	load the value at address $000A into register D
`ldaa #10`	load the decimal value 10 into register A
`ldaa #$B`	load the hex value B into register A
`ldaa #'B`	load the ASCII character code for B into register A
`ldaa #%10011001`	load the binary value 10011001 into register A
`ldd #label`	load the **address** value of *label* into register D
`ldaa label`	load the **data** value of *label* into register A
`ldaa Porte`	load the **data** from input Port E into register A
`const equ 2`	create a constant
`ldaa #const`	load the **data** value 2 into register A
`ldaa const,x`	load the **data** that is 2 bytes past the address in register X into register A
`ldaa 4,X`	load the **data** located 4 bytes past the location stored in register X into register A

Note the confusion we might have since `#10` and `label` and `#const` all denote data and `10` and `#label` denote addresses, and in the line `ldaa const,x` (*indexed addressing*), `const` is referring to data (2) again without the # sign. So although the # is significant in determining whether we are talking addresses or data, its meaning is not consistent in that regard. When the # sign is used it denotes the *immediate addressing mode* and this only occurs with load and compare commands (I think). So when we have the command `beq label`, label is an address even though the # sign is absent.

lds **Load Stack Pointer**

`lds #$00FF`		this example initializes the stack pointer; required if the stack is to be used; same value is normally used; goes near the top of the program after `org $E000`

lsr **Logical Shift Right** *Similar commands are* `lsra lsrb lsrd` *and for left shift:* `lsl lsla` *etc.* For use with unsigned numbers. See `asr` and related commands for use with signed values. A right shift divides by 2, a left shift multiplies by 2.

`lsr label`	divide the value pointed to by *label* by 2.
`lsra`	the contents of register A are shifted to the right one bit and bit 7 becomes zero.

mul **Multiply A × B = D** *Related commands are* `idiv fdiv`

`ldaa #10`	load 10 into register A
`ldab #5`	load 5 into register B
`mul`	the values are multiplied, result goes in register D (unsigned values only, no overflow is possible).

org **Sets the Program Counter, which specifies the address of the next byte to be loaded**

`org 0`	first program instruction
`org $E000`	follows global variables; moves to the beginning of the program area
`org $FFFE`	third from last command; makes room for a 2-byte reset address. The address stored here tells the CPU where to look for the beginning of the program when it is powered up.

psha **Push Register A onto Stack** *Similar commands are* `pshb pshx pshy`

`psha`	put the contents of register A on the stack and decrement the stack pointer; used for saving the contents of a register at the start of a subroutine, the registers are restored near the end of the subroutine using `pula pulb pulx puly`

pula **Pull from Stack to Register A** *Similar commands are* `pulb pulx puly`

`pula`	pull the value from the top of the stack and store in register A; increment the stack pointer; used for restoring the contents of a register at the end of a subroutine, the registers are saved near the beginning of the subroutine using `psha pshb pshx pshy`

rmb **Reserve Memory Bytes**

`label rmb 2`	creates a global variable or array, goes near the top of the program after `org 0.` Consists of the label name to be used for the memory location followed by `rmb` following by the number of bytes

rts **Return from Interrupt** *Similar command is* `rts`

`rti`	goes at the end of an interrupt routine, pulls all registers and the return address from the stack.

rts **Return from Subroutine** *Similar command is* `rti`

`rts`	goes at the end of a subroutine, pulls the return address from the stack.

sev **Set the V-bit**

`sev`	sets the V-bit to 1 in the condition code register (CCR)

staa **Store the value that is in Register A into . . .** *Similar commands are* `stab std sts stx sty`

`staa label`	store the value that is in register A in the memory location *label*

stop **Stop Program Execution**

`stop`	stops the program at this point

suba **Subtract from register A** *Similar commands are* `subb subd`

`suba label`	subtract the value stored at *label* from register A and store in register A
`suba #12`	subtract decimal 12 from register A and store in register A

tab **Transfer A to B** — transfers the value in register A to register B, leaving A intact

tcnt **Timer Counter Register** — a 2-byte register that increments once with each program instruction during execution

tsx **Transfer Stack Pointer to Register X** *Similar command* `txs`

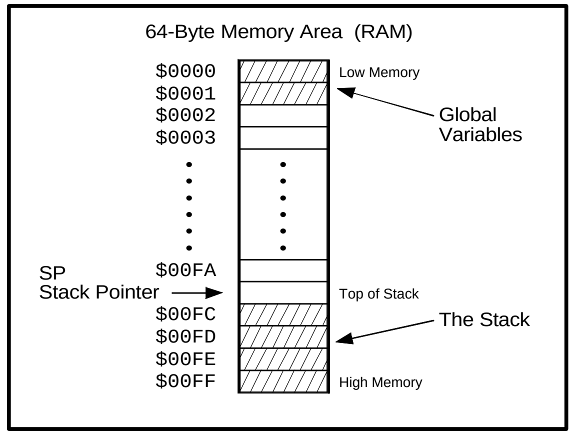
`tsx`	stores the address of the last value saved on the stack into register X. The stack pointer continues to point to the next empty byte, i.e. SP + 1 = X.

xgdx **Exchange D and X** — exchanges values in registers D and X. Commonly used to permit 16-bit arithmetic to be done on a register address.

MEMORY LOCATIONS

$0000 - $00FF RAM, 256 bytes. Globals and the Stack reside here. Globals are loaded at the **low** end, i.e. $0000, $0001, etc. The Stack is builds from the **high** end also referred to as the **bottom** of the stack, i.e. $00FF. The stack pointer points to the **top** of the stack, which is the first unused stack location, i.e. if $00FC contains the last stored data then the stack pointer points to $00FB.

$1000 - $103F Control registers, status registers and ports are mapped to this area



$1040 - $B5FF *Unused addresses*.

$B600 - $B7FF Internal EEPROM, 512 bytes for short programs

$B800 - $DFFF *Unused addresses*.

$E000 - $FFFF ROM, 8192 bytes. Object code and libraries go here. Libraries begin at $FE00 (a convention in this class) and interrupt vectors begin at $FFF6. Interrupt vectors are pointers to code to be implemented in the event of an interrupt. For example, the reset interrupt consists of the bytes $FFFE and $FFFF so this is where we put the address that tells the CU where to begin program execution on power-up.

PORTS

PortA ($1000) Pins 0, 1, 2 are inputs. Pins 3, 4, 5, 6 are outputs. Pin 7 is selectable by bit 7 of the pulse accumulator control register (Pact1) 0 = input, 1 = output.

PortB ($1004) Output.

PortC ($1003) Configurable as **input -** Ddrc = 0
latched input - Ddrc = 0, HNDS = 0
output - Ddrc = 1, CWOM = 0
open collector output - Ddrc = 1, CWOM = 1
The Ddrc is an 8-bit register so each bit of PortC can be set independently as either input or output.

PortD ($1008) Serial I/O **-** inputs and outputs are set by data direction register Ddrc.

PortE ($100A) Input - ADPU bit = 1 **-** A/D conversion.
ADPU bit = 0 **-** parallel input

SUBROUTINE LIBRARIES

InCh accepts input from the keyboard. When a key is pressed, the ASCII value is loaded in **register A** and the routine returns to the main program.

InDec accepts input from the keyboard. Returns an unsigned 16-bit number in **register D**. V-bit is set if illegal character is typed.

InHex accepts input from the keyboard as hex (must be 0-9, A-F, or a-f; ignored are space, tab and $). Result goes in **register D**.

InitSCI initializes the serial communications interface. Gets executed once near the beginning of the program. Watch the capitalization; instructor often gets this wrong on assignments.

```
jsr   InitSCI         Initialize the SCI port
```

InString accepts input from the keyboard. Before calling this routine, **register X** must point to a memory array and **register B** must contain the maximum length of the string. The string is inputted to the SCI window and stored in the array pointed to by register X; the last character is EOT=$04. The string array may be created as a global as follows:

```
Str   rmb   20         String variable
```

OutCh places the character in **register A** on the screen in the SCI window.

OutDec outputs a 16-bit number in **register D** to the SCI window.

OutHex outputs the contents of **register D** to the SCI window in unsigned hex format.

OutString displays a string in the SCI window. Before calling this routine, **register X** must point to a memory array containing the string, ending with EOT=$04. The following code may be used to produce the string. It is placed at the end of the program just before the last org command.

```
Label fcb  CR
      fcc  "My message here "
      fcb  EOT
```

Note that the quotation marks in "My message here " is not the only delimiter that can be used to mark the string. Any printable ASCII character other than ";" will work; whatever the first character is becomes the delimiter. EOT is defined as $04; it is the end of string character. The instructions above load values into ROM beginning at the current program location.

PARALLEL I/O CONTROL REGISTER (PIOC)

7	6	5	4	3	2	1	0	
STAF	**STAI**	**CWOM**	**HNDS**	**OIN**	**PLS**	**EGA**	**INVB**	PIOC $1002

STAF - Strobe A Flag

Set in response to STRA pin change of state, selectable rising or falling edge according to how the EGA bit is set. How the STAF is cleared depends on the selected handshake mode:

Simple Strobe Mode (HNDS=0) - clears when PORTCL is read
Full-Input Handshake Mode (HNDS=1, OIN=0) - clears when PORTCL is read
Full-Output Handshake Mode (HNDS=1, OIN=1) - clears when PORTCL is written to

STAI - Strobe A Interrupt Enable

0 - STAF interrupts are inhibited.
1 - A hardware interrupt request is generated whenever the STAF bit is set.

CWOM - Port C Wired-OR Mode

0 - Port C outputs are active push-pull drivers.
1 - Port C outputs are open-drain drivers.

HNDS - Handshake/Simple Strobe Mode Select

0 - Simple Strobe mode is selected; STRB is pulsed for 2 clock cycles after each write to port B (no handshaking).
1 - .either full-input or full-output handshake mode is selected; Port C is used.

OIN - Output/Input Handshake Select

HNDS must be 1 or there is no effect.
0 - full-input handshake is selected.
1 - full-output handshake is selected.

PLS - Strobe B Pulse Mode Select

Controls the configuration of the STRB pin. HNDS must be 1 or else STRB will default to pulsed mode.
0 - Interlocked mode; (HNDS must be 1) STRB will remain active until an edge is detected at the STRA pin.
1 - Pulsed mode; STRB is active for 2 clock cycles when triggered.

EGA - Edge Select for Strobe A

0 - falling edges are detected at the STRA input pin.
1 - rising edges are detected at the STRA input pin.

INVB - Invert Strobe B

0 - Negative logic; STRB signals are active low.
1 - Positive logic; STRB signals are active high.