Lecture 4: Addressing Modes

Today's Goals

Two major goals

- Understand addressing modes so figure out how to use them.
  - If you don't get addressing modes, you will have a serious problem to complete this course.
- Learn how to use a program trace.

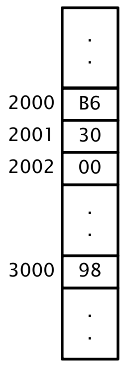
Addressing Modes

How to get effective addresses

- The operand of an instruction can use different methods for specifying data in the memory (=addressing modes).
  - If the data number is in registers (inside the microprocessor), a memory address is not needed.
- The HCS12 has six addressing modes
  - Extended (EXT)
  - Direct (DIR)
  - Inherent (INH)
  - Immediate (IMM)
  - Index (IDX)
  - Relative (REL) : Used only with branch instructions.
- Effective Address
  - The effective address is the location that holds the data to be used by the operation.
  - The operand is often used to construct the effective address.
  - An addressing mode tells the microprocessor the way of calculation to get the effective address.

Extended Addressing (EXT)

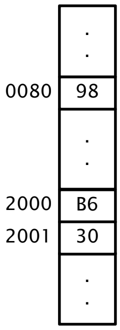
Also called Absolute Addressing



- Effective address:
  - No operation needed.
  - Extended addressing tells the full memory address.
- Format:
  - Two-byte hexadecimal number (4-digit) preceded with a $. Actually '$' simply means that the number is a hexadecimal number. (A number could be followed by 'h' excluding ''.
- Example:
  - (Assuming the instruction is stored at $2000)
  - LDAA $3000
    - Load a byte value stored at address $3000 into the register A.
    - LDAA *opr16a* (M) → A EXT B6 hh ll
    - 98 → A

Direct Addressing (DIR)

Also called Zero-Paging Addressing

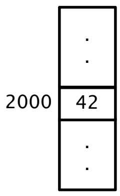


- Effective address:
  - This addressing mode only supplies the lower byte of the address.
  - Extend the one byte address to two-bytes by concatenating $00 to the beginning of the operand.
- Format:
  - One byte hexadecimal number (2-digit) preceded with a $.
- Example:
  - (Assuming the instruction is stored at $2000)
  - LDAA $80
    - Load a byte value stored at address $0080 into the register A.
    - LDAA *opr8a* (M) → A DIR 96 dd
    - 98 → A

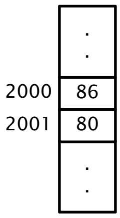
Inherent Addressing (INH)

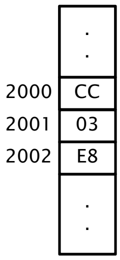
Also called Implied Addressing

- Effective address:
  - No operation.
- Format:
  - No operand.
- Example:
  - (Assuming the instruction is stored at $2000)
  - INCA
    - Increase register A by 1
    - INCA (A) + $01 → A INH 42



Immediate Addressing (IMM)





- Effective address:
  - No operation. The data itself is supplied as the operand.
- Format:
  - Number preceded with a #. '#' is followed by a number that is a <u>value</u> instead of an <u>address</u>!
- Example:
  - (Assuming the instruction is stored at $2000)
  - LDAA #$80
    - Load a byte value(the operand itself) into the register A.
    - 80_{16} ➔ A
  - LDD #1000
    - 1000 is $03E8_{16}$➔ D (meaning 03 → A and E8 → B)
- The size of an operand
  - Register A and B have one-byte immediate operands.
  - Register D, X, Y, SP, and PC have two-byte ones.

Index Addressing (IDX, IDX1, IDX2)

- Effective Address
  - Add the operand as a signed number to the value in the X, Y, PC, or S registers.
- Format
  - Signed number, Register (X, Y, PC, or S)
- Example:
  - LDAA 0,X
    - The effective address is the value(=address) in register X. (=X+0)
  - LDD -100,Y
    - The effective address is 100 lower than the value in Y. (=Y-100)
  - LDX 1000, Y
    - The effective address is 1000 higher than the value in Y. (=Y+1000)
- Notes:
  - The value in the specified register is not changed.
  - The smallest number of bits will be used to represent the address.

Index Addressing Postbytes

- An operand in the index addressing are called a postbyte.
- The postbyte tells the processor which two-byte register to be used as the base address, the size of the offset.

Register	rr
X	00
Y	01
SP	10
PC	11

Postbyte for 5-bit Offset: rr0nnnnn
Postbytes for 9-bit Offset: 111rr00n nnnnnnnn
Postbytes for 16-bit Offset: 111rr010 nnnnnnnn nnnnnnnn

Index Addressing

Examples

Instruction	Machine Code			
LDAA 4,Y	A6	44		
		01 0 **00100**		
LDD -100,X	EC	E1	9C	
		111 **00** 00 **1**	**10011100**	
LDX -1000,Y	EE	EA	FC	18
		111 **01** 010	**1111 1100**	**0001 1000**

Postbyte for 5-bit Offset: rr0nnnnn
Postbytes for 9-bit Offset: 111rr00n nnnnnnnn
Postbytes for 16-bit Offset: 111rr010 nnnnnnnn nnnnnnnn

Register	rr
X	00
Y	01
SP	10
PC	11

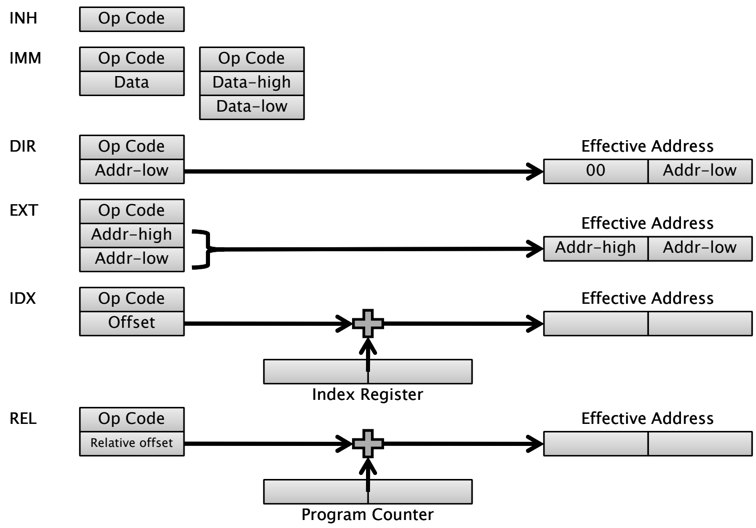
Instruction Set

Source Form	Operation	Addr. Mode	Machine Coding	Access Detail	S X H I	N Z V C
LDAA #opr8i	(M) ⇒ A	IMM	86 ii	P	- - - -	Δ Δ 1 0
LDAA opr8a	Load Acc. A	DIR	96 dd	rPf		
LDAA opr16a		EXT	B6 hh ii	rPO		
LDAA oprx0_xysp		IDX	A6 xb	rPf		
LDAA oprx9,xysp		IDX1	A6 xb ff	rPO		
LDAA oprx16,xysp		IDX2	A6 xb ee ff	frPP		

- Above is a portion of the entry for the LDAA instruction.
- Now, we can better understand information in the HCS12 instruction sets.

Addressing Mode Summary

How to Get an Effective Address



Program Trace

2000	B6	LDAA 3000h
2001	30	
2002	00	
2003	C6	LDAB #2
2004	02	
2005	18	ABA
2006	06	
2007	7A	STAA 3001h
2008	30	
2009	01	
200A	3F	“Stop”

3000	19
3001	FF

- A diagram showing the contents of the HCS12 memory which contains a program.
- A program trace shows the contents of the processor’s registers as the program is executed.
- Very useful for debugging programs

Program Trace

Example

Trace Line	Address	Instruction	PC	A	B
1	2000	LDAA 3000h	2003	19	-
2	2003	LDAB #2	2005	19	02
3	2005	ABA	2007	1B	02
4	2007	STAA 3001h	200A	1B	02
5	200A	“stop”	-	-	-

Program Trace

Another Example

2000	CE	LDX #3001H
2001	30	
2002	01	
2003	EC	LDD 1,X
2004	01	
2005	87	CLRA
2006	6C	STD -1,X
2007	1F	
2008	3F	“Stop”
3000	EC	
3001	27	
3002	45	
3003	99	

Trace Line	Address	Instruction	PC	X	A	B
1	2000	LDX #3001h	2003	3001	-	-
2	2003	LDD 1,X	2005	3001	45	99
3	2005	INCB	2006	3001	45	9A
4	2007	STD -1,X	2009	3001	00	9A
5	2009	“STOP”	-	-	-	-

- X requires a 2-byte operand with immediate addressing since it is a 2-byte register.
- Note that using indexed addressing to load/store register D does not change the value in register X.
- What are the values in memory locations from 3000h to 3003h after the program is done executing? 45-9A-45-99

Questions?

Wrap-up

What we've learned

- Five addressing modes
- Program trace

What to Come

- Unconditional branches
- Relative addressing mode