XA80

Assembler User Manual

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# Introduction

## Document purpose

This document is the User Manual for XA80, **X** (Cross) **A**ssembler for x**80** processors. Its purpose is to provide a reference on how the application should be used, with examples where appropriate.

Although XA80 is a multi-grammar assembler, all rules and examples presented in this document relate to the default XA80 grammar. Other grammars will have different rules, for example, around the naming of labels and expression processing.

Please refer to the XA80 Grammar Editor User Manual for more information on these topics.

## Application scope

XA80 is intended to be used with the following 8/16 bit processors:

* 8080
* 8085
* Z80
* Z180

Being open source, the software naturally lends itself to being extensible should other processor types or families be required.

# XA80 Line Structure

Main elements are:

* Labels
* Directives / Instructions
* Operands
* Comments

## Labels

The label takes the form of an alphabetic character or underscore followed by zero or more trailing characters. The trailing characters may be an alphabetic character, digit or underscore. Finally, this may suffixed by a colon ‘:’ to indicate a label. Examples are:

Start:

\_loop\_pos\_3:

KX0001:

Labels are case sensitive unless the command line switch -C has been used to switch this off. A label can exist in isolation with no other commands, in which case the value of the program counter is assigned to the label.

### Macro local labels

Labels used within a macro are always local to that macro.

MACRO LOOP\_TEST

LD HL, 2000H

LD B, 16

XOR A, A

loop: LD [HL], A

INC HL

DJNZ loop

ENDM

At expansion time the label is preceded by a local prefix purely for that expansion, for example:

LD HL, 2000H

LD B, 16

XOR A, A

@0001@loop: LD [HL], A

INC HL

DJNZ @0001@loop

### Directives / Instructions

Each code generating line will have a directive or an instruction. A directive could, for example, be DB (define bytes) which fills memory with a byte pattern or an instruction such as PUSH HL to push the HL register pair onto the stack.

The format is:

<label> or…

<optional\_label>  **<directive>**  <expression(s)> or…

<mandatory\_label> **<directive>** <expression(s)> or…

<optional\_label>  **<opcode>**  <operand(s)>

### Directives

A full list of directives is shown below. Some items are synonyms to allow flexibility with a wide range of source code material.

Mandatory label applies to the EQU, SET and = directives, all others are optional. See section **Error! Reference source not found.** for more details on how labels are used.

The list of directives is:

|  |  |  |  |
| --- | --- | --- | --- |
| Directive | Parameters | Description | Example |
| = | exprU16 or…  exprStr | Assigns a value to a mandatory label. Much like EQU, however the = construct can be used more than once while using EQU to redefine the value of a label would result in an error. | START = 0FFFAH  NAME = ‘John’ |
| ASMERROR | exprStr | Raises the error message listed in the string expression and halts the assembly | ERROR ‘Wrong!!!’ |
| ASMWARNING | exprStr | Issues the warning represented by the string expression | WARNING “No setup” |
| DB | list | Defines a series of bytes in memory. The expression list is a comma separated list of 8 bit numeric expressions which can include single or multiple characters enclosed in quotes | DB 12, 0FAH, -12, ’H’,”ello”, 0 |
| DC | listStr | Define Characters. Like DM however bit 7 of the last character in the string is set to 1. This is useful for lists of keywords etc. | DC “FOR”, “NEXT” |
| DEFB | Synonym for DB | | |
| DEFC | Synonym for DC | | |
| DEFM | Synonym for DB | | |
| DEFS | Synonym for DS | | |
| DEFW | Synonym for DW | | |
| DEFINE | symbol | Defines a symbol with a NULL value. The symbol must not exist already | DEFINE dump\_text |
| DM | Synonym for DB | | |
| DS | exprU16 | Define Storage. Reserves an amount of memory given by expression | DS 100H ; Reserve 256 |
| DS | exprU16, exprA8 | Define Storage, second form. Fills an area of memory with the first expression for a number of bytes determined by the second expression. | DS 100H,0AAH ; Bits  DS 10H,’ ‘ ; Spaces |
| DW | listA16 | Defines a series of words (16 bit) in memory. These are stored in a little-endian form | DW -1, 0C800H, 8192 |
| ELSE |  | Marks the end of an IF block and the start of a ELSE block |  |
| END |  | Marks the end of the assembly, does not need to be present |  |
| ENDIF |  | Marks the end of an IF or IF / ELSE block |  |
| ENDM |  | Ends a MACRO block |  |
| EQU | exprU16 or…  exprStr | Assigns the expression to the label. A label is mandatory with this directive | START EQU 0800H |
| IF | exprA16 | Evaluates the expression and if it’s zero the following lines are not assembled. Used in conjunction with the ELSE and ENDIF directives. IF statements can be nested. The expression must be known on the first pass or the assembly will fail | IF mask\_active |
| IFDEF | symbol | Similar to IF but activates the following code if the symbol exists | IFDEF DEBUG |
| IFNDEF | symbol | Similar to IF but activates the following code if the symbol does not exist |  |
| INCLUDE | filename | Includes the filename into the source file. The INCLUDE directive can be nested. By default, include files are not listed. | INCLUDE “foo.inc” |
| MACRO | name params | Defines a macro, concludes with a ENDM directive | MACRO foo from,to |
| MESSAGE | exprStr | Includes the message in the string expression into the assembly listing | MESSAGE “Complete” |
| ORG | exprU16 | Sets the assembly origin to the expression. A default value of 0 is used if this directive has not been used at all | ORG 2000H  ORG $+2 ; Reserve spc |
| UNDEFINE | symbol | Removes a symbol from the symbol table | UNDEFINE foo |

The case of the directive is not significant, for example SET has the same effect as Set.

### Instructions

Instructions are the elements which create the executable code, for example PUSH, LD, MVI. More detail is given in section 2.2 on opcodes and section 2.3 on operands.

## Opcodes

Opcodes can be any one of the 8080 / 8085 / Z80 / Z180 opcodes, for example LD or

RRCA. A full list of opcodes can be found in section 4.2

## Operands

There are three different styles of operand used with instructions which are handled by the application, these being 0 operands, 1 operand or 2 operands. Examples are:

|  |  |
| --- | --- |
| Operands | Examples |
| 0 | CCF  NOP  RETNZ |
| 1 | RST 0 |
| 2 | LD [HL],B |

### Simple operands

Simple operands are short and fixed definitions which typically refer to processor registers or flag conditions, the list is:

|  |  |  |
| --- | --- | --- |
| A  AF  AF'  B  BC  (BC)  C  (C)  D  DE  (DE) | E  H  HL  (HL)  I  IX  (IX)  IY  (IY)  L  M | NC  NZ  P  PE  PO  PSW  R  SP  (SP)  Z |

Not all operands are available on all processor types, for example PSW is available on 8080/8085, (IX) is available on Z80/Z180.

### Complex operands

Complex operands represent the index with offset operands, specifically:

(IX+signed\_displacement)

(IY+signed\_displacement)

### Expressions in operands

Expressions can form part or all of the operand. Some examples are:

CP A,’\_‘ ; Check if underscore

LD A, (IY+4) ; Get the byte parameter

LD HL, 2000H ; Point to start of buffer

LD C, (1 << 3) | 80H ; Set up initial value

There is a rich set of expression operators and function available, these are discussed in more detail in section 3.

### Operand indirection

Indirection is indicated by the ( ) characters, however it is converted internally into [ ] characters. Some legal examples:

LD HL,(SAVED) ; Get saved HL back

OUT (C),A ; Send byte to port

LD A,(IX+4) ; Get parameter byte

## Comments

Comments allow descriptive text to be added without influencing the operation of the assembler. There are two different types of comments available:

|  |  |  |
| --- | --- | --- |
| Style | Format | Description |
| 1a | optional\_text ; comment | Any text from a ; onwards will be treated as a comment. Text prior to the ; will be treated as valid information and will be processed by the assembler |
| 1b | optional text // comment | Any text from the // onwards will be treated as a comment |
| 2 | \* comment | A \* at the start of a line will process all following characters as a comment |

The following code example shows how comments can be used:

//

// ASSEMBLY FILE TEST

//

BIT\_MASK EQU 01101001B ; Use this to get correct flags

FACTOR EQU (10 + 3 {record offset!}) \* 2

; Code starts here

START:

XOR A,A ; Zero A

: :

# Expressions

Expressions can be integer expressions or string expressions

Expressions are formed from literal values, symbols, operators and functions. Examples are:

A > B

1 << bit\_5

2 + 3 \* 4

LOW(address)

15 \* (1 + 2)

Pos(“-“,title)

IIF(i>5,1,0)

build()

Left(title,3)

IIF(p==0,”Zero”,”Non-zero”)

## Literal values

Literal values can be:

1. Binary numbers, prefixed by %, 0b or suffixed with B. For example %01101001 or 0110B
2. Octal numbers, suffixed with letter O or Q. For example 123O or 777q
3. Decimal numbers – for example 123, 123D or 0
4. Hexadecimal numbers, which can be prefixed by #, 0x or suffixed by H[[1]](#footnote-1). For example $33A, $ff78 or 33AH[[2]](#footnote-2)
5. String values enclosed in single or double quotes, for example “MyString”
6. ASCII values of characters in single or double quotes, for example ‘A’ returns the hex value 65

## Symbols

Symbols are constant values or variables used within the assembly. They can be associated with:

* A null value
* An integer value
* A string value

A null value is produced by the DEFINE directive where a symbol is declared but has not specific value associated with it. It can only be used with IFDEF or IFNDEF directives.

## Operators and Expression Precedence

Expressions are evaluated using the following precedence:

|  |  |
| --- | --- |
| Precedence | Element |
| 1 | ( bracketed expression ) |
| 2 | String to integer functions |
| 3 | Symbols  Special symbols  Numeric functions  + unary plus  - unary minus  ~ Not operator |
| 4 | \* multiplication  / division  % modulo / remainder  & bitwise and  ^ bitwise xor  << shift left  >> shift right |
| 5 | + addition  - subtraction  | bitwise or |
| 6 | == comparison operators  !=  <  >  <=  >= |
| 7 | && boolean and  ^^ boolean xor |
| 8 | || boolean or |
| 9 | ! boolean not |
| 10 | = assignment operator |

## Integer Functions

These are functions returning an integer value. They may be dealing with strings.

|  |  |
| --- | --- |
| Function | Detail |
| HIGH(expression) | Returns the high byte of an expression (bits 8 to 15) |
| IIF(expression,true\_exp,false\_exp) | If the expression is non-zero, trueexp is returned otherwise falseexp is returned |
| LENGTH(string) | Returns the length of a string in characters |
| LOW(expression) | Returns the low byte of an expression (bits 0 to 7) |

## String Functions

A number of string functions are available within XA80:

|  |  |
| --- | --- |
| Function | Detail |
| DATE() | Return the date as a string in the form YYYY-MM-DD |
| IIF(expression,true\_exp,false\_exp) | If integer expression is non-zero, the string expression true\_exp is returned otherwise the string expression false\_exp is returned |
| LEFT(string,count) | Take the leftmost count characters from a string |
| LOWER(string) | Take the lower case value of string |
| MID(string,start,count) | Take the middle of a string from start for count characters |
| STRING(number) | Convert a number to a string value |
| RIGHT(string,count) | Take the rightmost count characters from a string |
| TIME() | Return the time as a string in the form HH:MM:SS |
| UPPER(string) | Return the upper case value of a string |
| VERSION() | Version string for the assembler |
|  |  |

# Appendices

## Appendix - Command Line Usage

From the program startup when invoking XA80 with no parameters:

XA80 Cross Assembler V0.1

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Usage: xa80 filename <options>

Options:

-b <bn> --debug=<bn> Set the debug name to <bn>

-c <cn> --com=<cn> Set the .com file name to <cn>

-d <id> --define=<id> Define one or more symbols

-e <en> --errorlog=<en> Set error log to <en>

-h --help Display this message

-I <id> --include=<id> Set the include directory to <id>

-l <ln> --listing=<ln> Set the listing name to <ln>

-m <mn> --map=<mn> Set the map filename to <mn>

-o <on> --object=<on> Set the object name to <on>

-p <pt> --processor=<pt> Use the nominated processor, default Z80

-r --redistribution Info on redistributing this software

-t <n> --tab=<n> Tab size for input file (default 4)

-v <n> --verbose=<n> Verbose output while assembling

-V --version Display version and other status info

-w --warranty Display warranty information

-x <hn> --hex=<hn> Set the hex filename to <hn>

<bn>/<cn>/<en>/<hn>/<ln>/<mn>/<on> default to the filename with ext

changed to .d80/.log/.hex/.lst/.map/.o80 respectively. Not specifying

<bn>, <cn>, <en>, <hn>, <ln>, <mn> or <on> will stop that output.

verbose <n> options:

0 Normal output levels (the default)

1 Verbose output

2 "War and Peace", lots more output

3 Debug level output

Processor type <pt> can be Z80 or Z180

The include file directory and define list <id> can contain names or

symbols delimited by ; for example:

--define=DEBUG;TAB\_SIZE=4;CODE\_NAME="Project ASM"

--include=source/tables;source/help;/users/me/includes

An example of the above would be:

xa80 myfile.z80 --listing=myfile --map=myfile --object=newprog --verbose=1

A full list of the parameters and their usage is as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| Short form | Long form | Action | Notes |
| -b <bn> | --debug=<bn> | Set the debug filename to <bn> | Not specifying a filename will cause the software to use the name sourcename.dbg. If the option is not used at all, no debug file is created |
| -c | --casesensitive | Make the processing of labels case sensitive | Labels are stored as uppercase by default. Using this flag allows case sensitive assembly to be used. Directives and opcodes are never case sensitive, irrespective of this flag |
| -d <list> | --define=<list> | Define a list of symbols | Valid use of <list> would be INC\_MONITOR or FLAG2;FLOPPY\_DRV;MASK\_ALL |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

## Appendix – Opcodes

The following opcodes are defined by the application:

| Opcode | 8080 | 8085 | Z80 | Z180 |
| --- | --- | --- | --- | --- |
| ACI | Y | Y |  |  |
| ADC | Y | Y | Y | Y |
| ADD | Y | Y | Y | Y |
| ADI | Y | Y |  |  |
| ANA | Y | Y |  |  |
| AND |  |  | Y | Y |
| ANI | Y | Y |  |  |
| BIT |  |  | Y | Y |
| CALL | Y | Y | Y | Y |
| CC | Y | Y |  |  |
| CCF |  |  | Y | Y |
| CM | Y | Y |  |  |
| CMA | Y | Y |  |  |
| CMC | Y | Y |  |  |
| CMP | Y | Y |  |  |
| CNC | Y | Y |  |  |
| CNZ | Y | Y |  |  |
| CP | Y | Y | Y | Y |
| CPD |  |  | Y | Y |
| CPDR |  |  | Y | Y |
| CPE | Y | Y |  |  |
| CPI | Y | Y | Y | Y |
| CPIR |  |  | Y | Y |
| CPL |  |  | Y | Y |
| CPO | Y | Y |  |  |
| CZ | Y | Y |  |  |
| DAA | Y | Y | Y | Y |
| DAD | Y | Y |  |  |
| DCR | Y | Y |  |  |
| DCX | Y | Y |  |  |
| DEC |  |  | Y | Y |
| DI | Y | Y | Y | Y |
| DJNZ |  |  | Y | Y |
| EI | Y | Y | Y | Y |
| EX |  |  | Y | Y |
| EXX |  |  | Y | Y |
| HALT |  |  | Y | Y |
| HLT | Y | Y |  |  |
| IM |  |  | Y | Y |
| IN | Y | Y | Y | Y |
| IN0 |  |  |  | Y |
| INC |  |  | Y | Y |
| IND |  |  | Y | Y |
| INDR |  |  | Y | Y |
| INI |  |  | Y | Y |
| INIR |  |  | Y | Y |
| INR | Y | Y |  |  |
| INX | Y | Y |  |  |
| JC | Y | Y |  |  |
| JM | Y | Y |  |  |
| JMP | Y | Y |  |  |
| JNC | Y | Y |  |  |
| JNZ | Y | Y |  |  |
| JP | Y | Y | Y | Y |
| JPE | Y | Y |  |  |
| JPO | Y | Y |  |  |
| JR |  |  | Y | Y |
| JZ | Y | Y |  |  |
| LD |  |  | Y | Y |
| LDA | Y | Y |  |  |
| LDAX | Y | Y |  |  |
| LDD |  |  | Y | Y |
| LDDR |  |  | Y | Y |
| LDI |  |  | Y | Y |
| LDIR |  |  | Y | Y |
| LHLD | Y | Y |  |  |
| LXI | Y | Y |  |  |
| MOV | Y | Y |  |  |
| MULT |  |  |  | Y |
| MVI | Y | Y |  |  |
| NEG |  |  | Y | Y |
| NOP | Y | Y | Y | Y |
| OR |  |  | Y | Y |
| ORA | Y | Y |  |  |
| ORI | Y | Y |  |  |
| OTD |  |  |  | Y |
| OTDM |  |  |  | Y |
| OTDMR |  |  |  | Y |
| OTDR |  |  | Y | Y |
| OTI |  |  |  | Y |
| OTIM |  |  |  | Y |
| OTIMR |  |  |  | Y |
| OTIR |  |  | Y | Y |
| OUT | Y | Y | Y | Y |
| OUT0 |  |  |  | Y |
| OUTD |  |  | Y |  |
| OUTI |  |  | Y |  |
| PCHL | Y | Y |  |  |
| POP | Y | Y | Y | Y |
| PUSH | Y | Y | Y | Y |
| RAL | Y | Y |  |  |
| RAR | Y | Y |  |  |
| RC | Y | Y |  |  |
| RES |  |  | Y | Y |
| RET | Y | Y | Y | Y |
| RETI |  |  | Y | Y |
| RETN |  |  | Y | Y |
| RIM |  | Y |  |  |
| RL |  |  | Y | Y |
| RLA |  |  | Y | Y |
| RLC | Y | Y | Y | Y |
| RLCA |  |  | Y | Y |
| RLD |  |  | Y | Y |
| RM | Y | Y |  |  |
| RNC | Y | Y |  |  |
| RNZ | Y | Y |  |  |
| RP | Y | Y |  |  |
| RPE | Y | Y |  |  |
| RPO | Y | Y |  |  |
| RR |  |  | Y | Y |
| RRA |  |  | Y | Y |
| RRC | Y | Y | Y | Y |
| RRCA |  |  | Y | Y |
| RRD |  |  | Y | Y |
| RST | Y | Y | Y | Y |
| RZ | Y | Y |  |  |
| SBB | Y | Y |  |  |
| SBC |  |  | Y | Y |
| SBI | Y | Y |  |  |
| SCF |  |  | Y | Y |
| SET |  |  | Y | Y |
| SHLD | Y | Y |  |  |
| SIM |  | Y |  |  |
| SLA |  |  | Y | Y |
| SLP |  |  |  | Y |
| SPHL | Y | Y |  |  |
| SRA |  |  | Y | Y |
| SRL |  |  | Y | Y |
| STA | Y | Y |  |  |
| STAX | Y | Y |  |  |
| STC | Y | Y |  |  |
| SUB | Y | Y | Y | Y |
| SUI | Y | Y |  |  |
| TST |  |  |  | Y |
| XCHG | Y | Y |  |  |
| XOR |  |  | Y | Y |
| XRA | Y | Y |  |  |
| XRI | Y | Y |  |  |
| XTHL | Y | Y |  |  |

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1. For hex literals, and B/H suffixes these are not case sensitive [↑](#footnote-ref-1)
2. Hex literals using the H suffix must start with a digit. This is to avoid confusion with labels as FABH could be a hex literal or a label. In this instance, use 0FABH to make it clear to the assembler that this is a literal value [↑](#footnote-ref-2)