

Chapter 4.1 Introduction to Development Systems

Objectives of this Chapter

Having studied this chapter you will be able to:

- Use the Merlin Text Editor to enter 80286 assembly language program mnemonics
- Explain the use of the ORG assembler directive
- Assemble an object program from within the Merlin environment.
- Transfer an object program from the PC to the PAT
- Use the Terminal Commands to:
 - Examine the contents of PAT memory
 - Modify the contents of PAT memory
 - Execute an object program
- Describe the operation of the 80286 instructions:
 - Subtract
 - Exchange

Introduction

Recall that an **assembler** will examine the text of a source program and convert any 80286 instructions which it recognizes into 80286 machine code.

It will also alert you to any text it does not recognize and any instructions which have incorrect form. Any line which begins with a semi-colon (;) will be **ignored** by the assembler. This allows you to put **comments** in your programs. Many 80286 instructions require one or more **operands** to be specified. The operands specify the data which is to be operated upon. These are stated **after** the instruction mnemonic in the order **destination,source**.

An operand may be specified as a **label**. This is predefined text used in place of a value or memory location. This technique is discussed a little later.

The last part of an assembly language line is a **comment**. Comments are totally ignored by the assembler, but are a very important aid to understanding the program.

Assembly language programs tend to be quite difficult to follow if comments are omitted. Comments will help you to remember the function of a given section of code. Since the assembler ignores the comments, they do not cause the object program to become longer or reduce the speed of execution.

Using the Text Editor to Create 80286 Source Programs

You will now use Merlin to generate a source program. Enter Merlin and give your program a name, say PROG1.ASM.

If you are using a dual floppy disk machine then drive A will be used for your program files unless you specify an alternative drive in the file path.

If you are using a hard disk machine then the subdirectory \80286 that you created in the last chapter will be used for your program files, unless you specify an alternative file path.

You should now see the Merlin screen and your filename in the top right hand corner.

Enter the simple program below. Notice how a semi-colon (;) is used to define a comment.

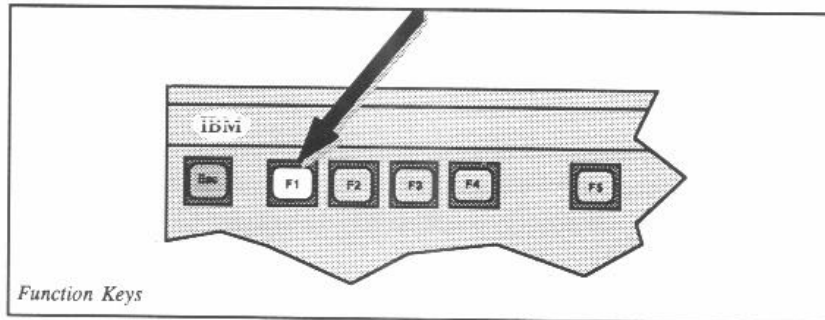
```
; Prog1
; This program will add 1234H to the word at location
; 0080:1000H and save the result at address 0080:1100H
    MOV AX,DS:1000H ;Moves the contents of location
                    ;0080:1000H into the AX Register
    ADD AX,1234H    ;Adds the value 1234H to the AX Register
    MOV DS:1100H,AX ;Saves the result in memory location
                    ;0080:1100H
    MOV BX,0000H   ;Returns to PAT system
    MOV AH,04H
    INT 28H
```

Now, the start address for object code must be defined. A special instruction to the assembler (an assembler **directive**) is used for this purpose.

The "**ORG**" (Origin) directive defines the start address for object code. Insert "ORG 0100H" at the beginning of your program thus:

```
; Prog1
; This program will add 1234H to the word at location
; 0080:1000H and save the result at address 0080:1100H
    ORG 0100H      ;Defines the start address for
                    ;object code as 0080:0100H
    MOV AX,DS:1000H ;Moves the contents of location
                    ;0080:1000H into the AX Register
    ADD AX,1234H    ;Adds the value 1234H to the AX Register
    MOV DS:1100H,AX ;Saves the result in memory location
                    ;0080:1100H
    MOV BX,0000H   ;Returns to PAT system
    MOV AH,04H
    INT 28H
```

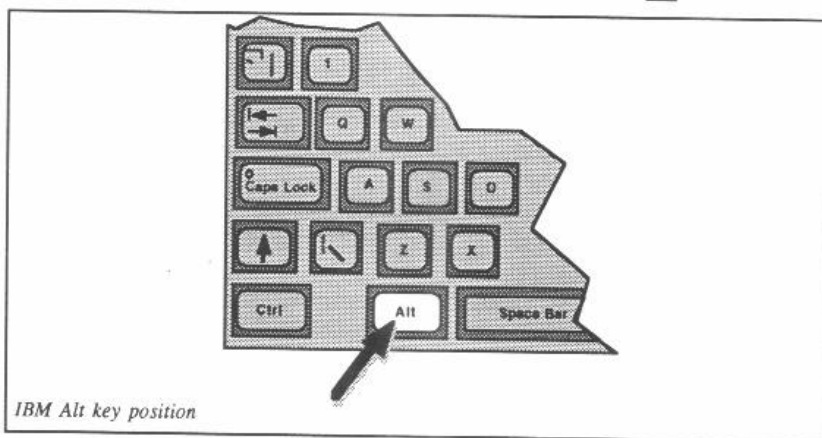
When you have completed this source program you can save your file by pressing the function key **F1**.



The D2000 80286 Cross Assembler User Manual gives a more detailed description of Merlin's facilities.

Assembling an Object Program

It is now necessary to **assemble** the object code from your source program. Hold down the **Alt** key and then press and release the **A** key (Alt-A).



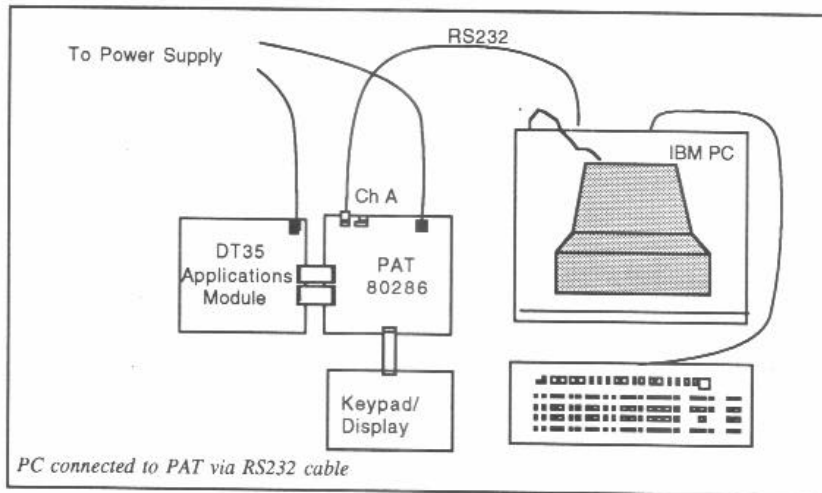
If the assembler finds no errors in your program, the screen will show:

No errors

When you see this message, an object program has been assembled and saved on disk.

Loading Object Programs

To transfer your 80286 object code program from the PC to the PAT, we must enter the "Terminal" mode. Firstly, ensure that the PC and PAT are connected via the RS232 cable supplied with the D2000 Cross Assembler, as shown below:



Now, hold down the **Alt** key, then press and release the **T** key (Alt-T).

You will then see the terminal screen. Press "reset" on the PAT board and the screen will show:

```
LJ Technical Systems PAT 80286 V1.1
M <address> - Display one page of memory
C <address> - Change memory contents
G <address> - Execute a program
T <address> - Trace instruction and display registers
L          - Load file from cassette or RS232 into memory
H+        - Display the full help screen
PAT: _
```

You are now in the **Terminal Mode**. In this mode the PC displays any character received through its serial port, from the target board. Also, any commands entered at the PC keyboard are transmitted to the target board.

In effect, the PC is behaving as the keyboard and display of the PAT.

Thus any key pressed on the PC keyboard is interpreted as a command by the PAT. The PAT will then respond by displaying information on the PC screen.

The exception to this rule is when a key is pressed while the [Alt] key is held down (e.g. [Alt]-S). Commands of this type do not cause the PAT to respond, but instead invoke special functions built into the PC.

The on-line "Help" facility can prove a useful reference. Enter "H" and the screen will display the short help shown above. If you enter "H+", the screen will display the complete set of Terminal Commands.

Now, enter "L" and the PAT will respond "Loading...".

Hold down the **[Alt]** key and then press and release the **[S]** key (Alt-S).

The cursor will now be in the bottom right-hand corner of the screen. The file to be transmitted is shown in this area. If required you could now change this but it should already show "PROG1.OBJ". Press the **[Return]** (**[Enter]**) key and after a short delay the PAT will respond "Loaded". This indicates that the PC has transmitted the object program to the PAT.

Examining the Contents of Memory

Check that the program has been loaded into PAT memory by pressing

[M] **[0]** **[1]** **[0]** **[0]**. The display will then show:

0080:0100	3E A1 00 10 05 34 12 3E A3 4C 04 BB 00 00 B4 04	>....4.>.L.....
0080:0110	CD 28 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.(.....
0080:0120	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0080:0130	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0080:0140	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0080:0150	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0080:0160	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0080:0170	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0080:0180	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0080:0190	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....

This indicates that the data at address 0080:0100_H is 3E_H, the word at 0080:0101_H is A1_H, the word at 0080:0102_H is 00_H and so on.

Notice that the extreme right-hand column shows the **ASCII** equivalent of the contents of each memory byte. The default address for memory display is 0080:0100_H.

You can examine any area of PAT memory by entering the start address after the "M". For example, "M 0200" will display the contents of PAT locations 0080:0200_H to 0080:0290_H.

The amount of memory shown on the screen can be altered by adding a semi-colon and the number of bytes to the command. For example, "M 2000;8" will display eight bytes from location 0080:0200_H thus:

```
0080:0200  00 00 00 00 00 00 00 00
```

(Assuming that this area of RAM has not been changed since the start of the session).

Changing the Contents of Memory

The contents of a memory location can be changed from within the Terminal Mode by using the "C" command. Enter "C 0200". The PC screen will show:

```
0080:0200  : 00  _
```

Enter the value **AB** and press Return. The screen will show:

```
0080:0200  : 00 AB
0080:0201  : 00  _
```

You have changed the contents of location 0080:0200_H to AB_H and can now change the contents of location 0080:0201_H.

We will now change the contents of this location to CD_H. Type in **CD**, so that the display shows:

```
0080:0200  : 00 AB
0080:0201  : 00 CD
```

Place a colon (:) after "CD" to terminate the "C" command, then press Return. The "PAT:" prompt will reappear:

```
0080:0200  : 00 AB
0080:0201  : 00 CD
PAT:  _
```

The "C" command can also be used in a different way. Enter "C 2000" and the screen will show again:

```
0080:0200  : AB  _
```

Now key in the following data in bytes, separated by a **space** thus:

```
0080:0200  : AB 01 23 45 67 89:
```

Notice once again that a colon (:) is used to terminate the "C" command.

Press the Return key to enter the data. Use the "M" command to examine the contents of 0080:0200_H and the following locations.

The first few lines of the display should now show:

0080:0200	01 23 45 67 89 00 00 00 00 00 00 00 00 00 00 00	.#Eg.....
0080:0210	CD 28 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0080:0220	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....

So, the "C" command can be used to change **single** or **multiple** bytes of memory.

Another way of using the "C" command is to enter ASCII codes **directly** into memory. For example, to enter the ASCII codes for the message "Hello" from location 0080:0300_H:

Enter "C 0300" and type the ASCII characters in between quotation marks thus:

```
0080:0300 : 00 "HELLO":
```

Followed by .

Use the "M" command thus "M 0300;5" and the screen will show:

```
0080:0300 :48 45 4C 4C 4F      Hello
```

The PAT User Manual further describes this facility.

Running Object Programs

Recall that "PROG1" will add 1234_H to the contents of location 0080:1000_H and save the result in location 0080:1100_H. Since the data is 16 bits long (1234_H), **word** location 0080:1100_H is made up from **byte** locations 0080:1100_H and 0080:1101_H.

Before running this program, we must ensure locations 0080:1000_H and 0080:1001_H contain known data. Use the "C" command to change the data in these locations thus:

```
0080:1000 78  
0080:1001 56
```

Enter "G" to run your program. The default value for execution is 0080:0100_H. You can execute from any location by entering the start address after the "G". For example, "G 0200" will execute from location 0080:0200_H. Having run your program from 0080:0100_H, use the "M" command to examine memory locations 0080:1100_H and 0080:1101_H. You should find that these have been modified to:

```
0080:1100 AC  
0080:1101 68
```

This is to be expected, since $1234_{\text{H}} + 5678_{\text{H}} = 68\text{AC}_{\text{H}}$.

To return to Merlin, hold down the key and then press and release the key (Alt-X).

So, you can now write and edit source programs, assemble these into 80286 object code and transfer programs to the PAT.

The D2000 80286 Cross Assembler User Manual gives further details of the options which may be used.

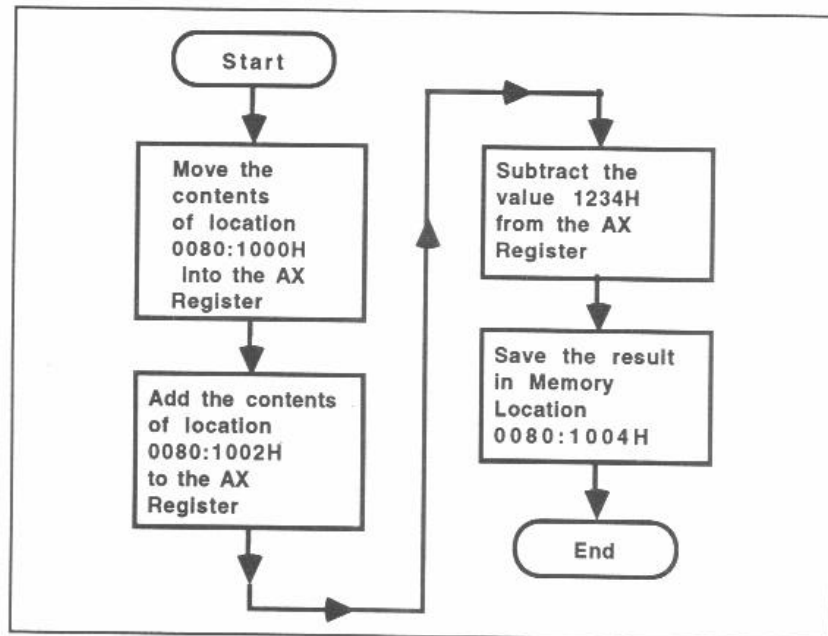
Exercise 3

Write a program, starting at location 0080:0100H, which will add the 16 bit words at memory locations 0080:1000H and 0080:1002H, then subtract the value 1234H from the sum. The final result should be saved at location 0080:1004H.

Solution:

This problem will require a "subtract" instruction. The SUB instruction subtracts the source operand from the destination operand and then saves the result in the destination.

Flowchart:



The assembly language source program is shown on the next page:

```

ORG 0100H      ;Defines the start address for
                ;object code as 0080:0100H

MOV AX,DS:1000H ;Moves the contents of location
                ;0080:1000H into the AX Register
ADD AX,DS:1002H ;Adds the contents of location 0080:1002H
                ;to the AX Register
SUB AX,1234H   ;Subtracts the value 1234H from the AX
                ;Register
MOV DS:1004H,AX ;Saves the result in memory location
                ;0080:1004H
MOV BX,0000H   ;Returns to PAT system
MOV AH,04H
INT 28H

```

Use the Merlin Text Editor to enter this source program and give the file a relevant name (eg: PROG2.ASM, EX03.ASM, etc.).

Assemble the object program from within Merlin by pressing "Alt-A". Provided there are no errors in the source program, the assembler will produce an object program file. If there are any errors in the source program, Merlin will send appropriate error messages to the screen and indicate the line in which the error has occurred. Once error-free assembly is achieved, enter the Terminal mode by pressing "Alt-T" and then press the reset key on the PAT board. The PC screen should now show the "PAT: _" prompt.

Transfer the object program to the PAT by using the "L" command: Enter "L" and then press "Alt-S" and "Return". The screen will show a message when the program has been loaded into PAT memory. Now, to check for correct operation, load locations 0080:1000_H to 0080:1003_H with **known** data before executing the program. So, for example, modify these locations as follows:

Location	Contents
0080:1000 _H	28 _H
0080:1001 _H	4C _H
0080:1002 _H	FD _H
0080:1003 _H	17 _H

Run the program from the start address 0080:0100_H using the command "G 0100".

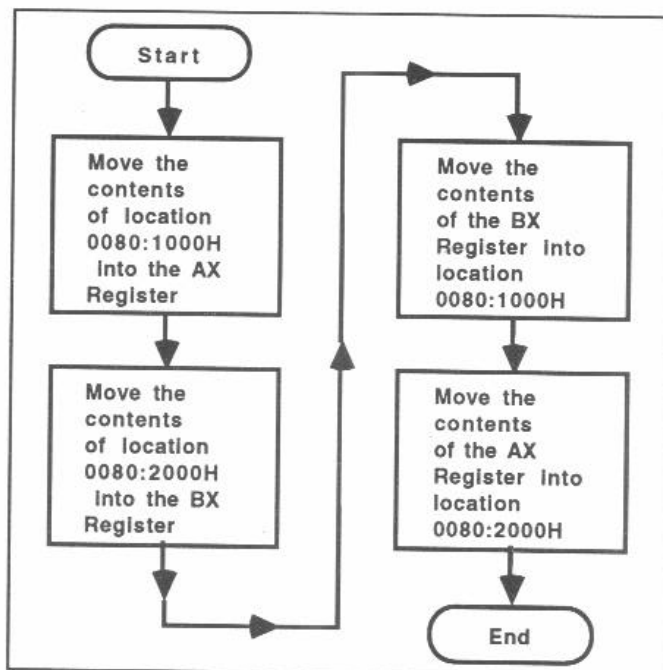
Now use the "M" command to examine the data at locations 0080:1004_H and 0080:1005_H. You should find that the word is 51F1_H (since 4C28_H + 17FD_H - 1234_H = 51F1_H). If you do not find this value, check that the source program is correct and the values in locations 0080:1000_H to 0080:1003_H.

Exercise 4

Write a program, starting at location 0080:0200_H, which will exchange the 16 bit words at memory locations 0080:1000_H and 0080:2000_H.

Solution:

Flowchart:



The assembly language source program is shown opposite:

```
ORG 0200H           ;Defines the start address for
                   ;object code as 0080:0200H

MOV AX,DS:1000H     ;Moves the contents of location
                   ;0080:1000H into the AX Register
MOV BX,DS:2000H     ;Moves the contents of location
                   ;0080:2000H into the BX Register
MOV DS:1000H,BX     ;Moves the contents of the BX Register
                   ;into location 0080:1000H
MOV DS:2000H,AX     ;Moves the contents of the AX Register
                   ;into location 0080:2000H

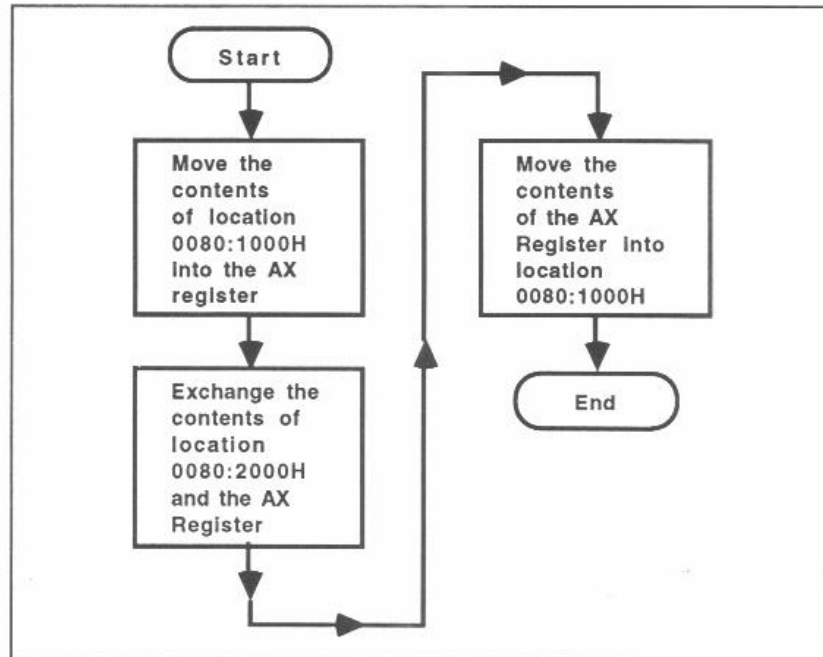
MOV BX,0000H       ;Returns to PAT system
MOV AH,04H
INT 28H
```

Create a source program, using the Merlin Text Editor and assemble the object program. Transfer the object program to the PAT and place words of known value in locations 0080:1000_H and 0080:2000_H.

Run the program and verify correct operation by examination of the words in locations 0080:1000_H and 0080:2000_H before and after program execution.

This problem could have been approached in a different manner. The 80286 has an "exchange" instruction which allows the contents of two Registers (or a Register and a memory location) to be exchanged.

A flowchart for this approach is shown on the next page.



The assembly language source program will be:

```

ORG 0200H          ;Defines the start address for
                   ;object code as 0080:0200H

MOV AX,DS:1000H    ;Moves the contents of location
                   ;0080:1000H into the AX Register
XCHG AX,DS:2000H  ;Exchanges the contents of location
                   ;0080:2000H and the AX Register
MOV DS:1000H,AX    ;Moves the contents of the AX Register
                   ;into location 0080:1000H
MOV BX,0000H      ;Returns to PAT system
MOV AH,04H
INT 28H
    
```

Create a source program, using the Merlin Text Editor and assemble the object program. Transfer the object program to the PAT and run the program. Verify correct operation again by examination of the words in locations 0080:1000_H and 0080:2000_H, **before** and **after** program execution.

Student Assessment 4

1. The ORG assembler directive is used to:
 - a return to the PAT system
 - b assemble an object code program
 - c define the start address for an object code program
 - d generate error messages

2. The Merlin key sequence required to enter the Terminal Mode is:
 - a Alt-A
 - b Alt-L
 - c Alt-S
 - d Alt-T

3. The Terminal Mode key sequence required to modify the byte at location 0080:5000_H is:
 - a C 5000
 - b D 5000
 - c G 5000
 - d M 5000

4. The 80286 Assembly Language instruction which subtracts 05_H from the BH Register is:
 - a SUB 05H,BH
 - b SUB BH,05H
 - c SUB BYTE PTR 05H,BH
 - d SUB BH,BYTE PTR 05H

5. The 80286 Assembly Language instruction which exchanges the AX and BX registers is:
 - a EXCH AX,BX
 - b SWAP AX,BX
 - c XCHG AX,BX
 - d XLAT AX,BX