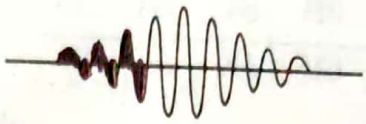
5



Debug and Assembler

DEBUG is a program which allows the programmer to write, execute and debug assembly language programs, and to examine the contents of registers and memory. It can also be used to run a program, one instruction at a time. ASSEMBLER is also a program for the same purpose but is more powerful and provides more facilities as compared to DEBUG.

5.1 DEBUG

To start DEBUG its name is typed after DOS prompt as shown below:

```
C:\>DEBUG
-
```

'Enter' key after a command.

If DEBUG program is in subdirectory its name is typed as follows:

```
C:\>CD\DOS
C:\>DOS\DEBUG
-
```

The hyphen shown above is DEBUG prompt.

5.2 DEBUG COMMANDS

DEBUG has a number of commands to facilitate users to write, execute and debug programs. Each command is designed to perform an important task. There are commands to assemble and execute programs, display the contents of registers and memories, to run a program in single step mode, etc.

A DEBUG command is represented by a one-letter symbol. For example: A for assemble, E for entry, D for display, etc.

5.2.1 Assemble Command, A

The A command allows you to enter mnemonics of an assembly language program and converts it into machine codes. When A command is executed, the machine codes are generated and directly stored in the memory. They are not displayed on the screen. To display machine codes on the screen the U command is used. It will be discussed in the next subsection.

After getting DEBUG prompt the starting address is initialized as

- A address

Suppose we take 0100 as the starting offset address, then the above step will be written as

```
- A 0100
```

When the above command is executed the next line will show:

```
1584 : 0100
```

If offset is not provided, the DEBUG will take offset by default and it is 0100. The default address is CS : 0100. 1584 is the content of the code segment register CS. It may be some other number also. 0100 is the offset in the code segment. Now a mnemonic in this line and Enter key pressed as shown below:

```
1584 : 0100 MOV AX, 0012
```

The next line will show as:

```
1584 : 0103
```

In the above line you can enter the next mnemonic of your assembly language program. A simple program will be written as follows:

```
-A 0100
1584 : 0100 MOV AX, 0012
1584 : 0103 MOV BX, 1253
1584 : 0106 MOV CX, 2485
1584 : 0109 MOV DX, 1548
1584 : 010C MOV SI, 3412
1584 : 010F MOV DI, 7856
1584 : 0112 INT 3
1584 : 0113
-
```

At the memory location 1584 : 0113 the DEBUG is ready to accept another mnemonic. If you want to enter a mnemonic, you enter it and press Enter. It will go in the next line. If you do not want to enter any

mnemonic at this point, rather you want to terminate the A command and end your program, you just press Enter after 1584 : 0113. It will exit the A command and show the DEBUG prompt, a hyphen as shown in the above program.

One can change the instruction of a program at any memory address. For example, the instruction INT 3 at 1584 : 0112 can be changed to ADD AX, BX :

```
- A 0112
1584 : 0112 ADD AX, BX
1584 : 0114
-
```

5.2.2 Unassemble Command, U

The U command disassembles machine codes of specified memory addresses and gives corresponding mnemonics. It displays machine codes as well as corresponding mnemonics on the screen. Its default register is the CS : IP. Its general format is

U address range

We have already written a simple program and its machine codes are stored in the memory from 1584 : 0100 to 1584 : 0112. We can unassemble these machine codes as follows:

```
-U 0100 0112
```

This command will show the unassembled program as shown below:

```
-U 0100 0112
1584:0100 B81200  MOV AX,0012
1584:0103 BB5312  MOV BX,1253
1584:0106 B98524  MOV CX,2485
1584:0109 BA4815  MOV DX,1548
1584:010C BE1234  MOV SI,3412
1584:010F BF5678  MOV DI,7856
1584:0112 CC  INT 3
-
```

Adjacent machine codes (hex codes) are displayed in continuation without any space between them. 1584 is the content of CS. It comes by default.

The address range with U command can also be given in the following format

```
U 0100 L10
```

This command will unassemble 16 (10 hex) bytes starting from CS:0100.

If U command is given with only one address in stead of an address range, DEBUG unassembles 32 bytes starting from the given address.

```
-U 0100
1584:0100 B81200  MOV  AX,0012
1584:0103 BB5312  MOV  BX,1253
1584:0106 B98524  MOV  CX,2485
1584:0109 BA4815  MOV  DX,1548
1584:010C BE1234  MOV  SI,3412
1584:010F BF5678  MOV  DI,7856
1584:0112 CC  INT  3
1584:0113 CC  INT  3
1584:0114 CC  INT  3
1584:0115 CC  INT  3
1584:0116 CC  INT  3
1584:0117 CC  INT  3
1584:0118 B209  MOV  DL,09
1584:011A 99  CWD
1584:011B 007315  ADD  [  BP+DI+15  ],DH
1584:011E 7315  JNB  0135
-
```

If U command is given without specifying any address, DEBUG unassembles 32 bytes starting from the address contained in the IP register or it unassembles 32 bytes since last U, if any. The default register for U command is the CS:IP.

5.2.3 Register Command, R

The R command is used to display the contents of one or more registers. It also displays the status of the flags. The general format of the command is

R [register name]

If the R command is given without a name of a register, the DEBUG displays the contents of all registers.

```
-R
AX=1254  BX=5938  CX=0000  DX=0012  SP=FFEE  BP=0000  SI=0000  DI=0000
DS=20A9  ES=20A9  SS=20A9  CS=20A9  IP=0100  NV  UP  EI  PL  NZ  NA  PO
NC
20A9:0100  B81200  MOV  AX,0012
-
```

If R command is given with a name of a register, the name and the content of that register is displayed in the next line. A colon is then

displayed as a prompt in the subsequent line. Now a value after the colon is typed to change the register and then Enter key is pressed. Thereafter, the debug prompt is displayed. If you do not want to change the content of the register, press Enter key. The old value will remain in the register. To see the changes you have made, give R command or 'R register-name' command again.

```
-R  AX
AX  1254
:2415
-R  BX
BX  5938
:3498
-R  IP
IP  0100
:0200
-
```

If you type an invalid register-name, an error message BR will be displayed.

Status Flags The status flags with their codes for SET and CLEAR are given in Table 5.1.

Table 5.1 Status Flags

Name of the flag	*SET*	*CLEAR*
Overflow	OV	NV
Direction	DN (Decrement)	UP (Increment)
Interrupt	EI (Enabled)	DI (Disabled)
Sign	NG (Negative)	PL (Positive)
Zero	ZR	NZ
Auxiliary Carry	AC	NA
Parity	PE (Even)	PO (Odd)
Carry	CY	NC

We have already seen that when R command is given without a register-name the status of flags along with the contents of all other registers are displayed. If we want to change a flag-status, we can give a command as follows:

```
-R  F
```

F is register-name to see the flags. Now the status of the flags are displayed in the beginning of the next line in the form of codes as mentioned above. At the end of the list of status of the flags, the debug displays a hyphen (-). Now after the hyphen you can type changed status

of the desired flags in any order, and then press Enter key. The sequence of giving commands is as follows:

```
-R F
```

It will show:

```
NV UP EI PL NZ NA PO NC -
-
```

Now enter desired status of the desired flags after hyphen as

```
NV UP EI PL NZ NA PO NC - OV CY DI
-
```

To see the changed condition give R F command again.

```
-R F
```

It will show:

```
OV UP DI PL NZ NA PO CY -
-
```

Any flags for which new values are not given remain unchanged. If more than one value for a flag is given, debug returns an error message, DF. If an invalid flag-code is given, the debug returns a BF error message. In both the cases, the flags up to the error in the list are changed. The flags at and after the error remain unchanged.

5.2.4 Go Command, G

The G command is used to execute a program. Its general format is

G = address

The equal sign (=) put before the specified address indicates that the given address is the starting address. The default register for G command is the CS. We can take a program as shown below:

```
-A 0100
1584 : 0100 MOV AX, 0012
1584 : 0103 MOV BX, 1253
1584 : 0106 MOV CX, 2485
1584 : 0109 MOV DX, 1548
1584 : 010C MOV SI, 3412
1584 : 010F MOV DI, 7856
1584 : 0112 INT 3
1584 : 0113
-
```

To execute the program and to see the results, give the command as follows

```
-G = 0100
```

The above command will execute the program starting from the address CS:0100, and show the contents of all register, flags, etc. as shown below:

```
-G = 0100
AX=0012 BX=1253 CX=2485 DX=1548 SP=FFFF BP=0000 SI=3412 DI=7856
DS=159C ES=159C SS=159C CS=159C IP=0112 NV UP EI PL NZ NA PO
NC
159C:0112 CC INT 3
-
-G
```

If G command is given without any address, it executes program starting from the address CS:IP.

Break-Point The G command is also used to provide a break-point in a program. The format is

G address

The above command executes the program starting from the offset address contained in the register IP. In the other words the starting address is CS:IP. The execution breaks (i.e. ends) at the given address. For example, we can give a command as follows:

```
-G 0109
```

This command will execute our program of Section 5.2.1 starting from the offset address [IP] up to the offset address 0108. With IP = 0100, the result is as follows:

```
-G 0109
AX=0012 BX=1253 CX=2485 DX=1548 SP=FFFE BP=0000 SI=0000 DI=0000
DS=159C ES=159C SS=159C CS=159C IP=0109 NV UP EI PL NZ NA PO NC
159C:0109 BA4815 MOV DX,1584
-
```

G = address address

If the above command is given it will execute program starting from the first address and provide break-point at the second address.

Example

```
-G = 0103 0109
```

The above command executes program from CS:0103 to CS:0108 and provides break-point at CS:0109.

5.2.5 Trace Command, T

The command T is used to run a program in single-step mode. The default register is the CS:IP and the general format is

T = address

For testing the above command we can write a simple program as shown below

```
-A 0100
1584:0100 MOV AX,0012
1584:0103 MOV BX,1253
1584:0106 MOV CX,2485
1584:0109 MOV DX,1584
1584:010C INT 3
1584:010D
-
```

To execute the above program in single-step mode the following command is given:

```
-T = 0100
```

The above command will execute the first instruction of the program and show the result as

```
-T = 0100
AX=0012 BX=0000 CX=0000 DX=0000 SP=FFFE BP=0000 SI=0000 DI=0000
DS=159C ES=159C SS=159C CS=159C IP=0103 NV UP EI PL NZ NA PO
NC
159C:0103 BB5312 MOV BX,1253
-
```

The last line of the result shows the next instruction which is to be executed. To execute the next instruction the T command is given in the following format:

```
-T
```

In the above command address of the instruction to be executed will be taken by default. The address which is in the register IP, i.e. 0103 will be taken by default. The results are as follows:

```
-T
AX=0012 BX=1253 CX=0000 DX=0000 SP=FFFE BP=0000 SI=0000 DI=0000
DS=159C ES=159C SS=159C CS=159C IP=0106 NV UP EI PL NZ NA PO
NC
159C:0106 B98524 MOV CX,2485
-
```

Using **T = address** command any instruction of the program can be executed. For example, if we want to execute the instruction at the memory location 1584:0106 MOV CX,2485 only, the following command will be given:

```
-T = 0106
```

Before giving this command the contents of the register AX, BX and CX have been set to zero. After execution of the above command the result is as follows:

```
-T = 0106
AX=0000 BX=0000 CX=2485 DX=0000 SP=FFEE BP=0000 SI=0000 DI=0000
DS=159C ES=159C SS=159C CS=159C IP=0109 NV UP EI PL NZ NA PO NC
20A9:0109 BA4815 MOV DX,1548
-
```

To execute more than one instruction by a single command in single-step mode the general format of the T command is

T = address value

Here value = *n*, where *n* is the number of instruction to be executed by single command in single-step mode.

To execute two instructions of the test program under consideration we can give command as follows:

```
-T = 0100 02
```

Before giving this command set the contents of AX, BX and CX equal to zero for testing the sample program.

The above command executes the first instruction MOV AX,0012 and prints its result. Thereafter, the second instruction MOV BX,1253 is executed and its result is printed. Results are as follows:

```
-T = 0100 02
AX=0012 BX=0000 CX=0000 DX=0000 SP=FFFE BP=0000 SI=0000 DI=0000
DS=159C ES=159C SS=159C CS=159C IP=0103 NV UP EI PL NZ NA PO NC
159C:0103 BB5312 MOV BX,1253
AX=0012 BX=1253 CX=0000 DX=0000 SP=FFFE BP=0000 SI=0000 DI=0000
DS=159C ES=159C SS=159C CS=159C IP=0106 NV UP EI PL NZ NA PO NC
159C:0106 B98524 MOV CX,2485
-
```

5.2.6 Display or Dump Command, D

The D command is used to display the contents of specified memory locations. The default register is DS. Its general format is

D address range or D address

With address range the D command is given as follows:

```
-D 0100 0120
```

The above command will show the contents of the memory locations from DS:0100 to DS:0120 as shown below:

```
-D 0100 0120
```

```
2000:0100  E0  23  C0  7E  2C  3D  FE  00-7E  0C  C7  46  E0  FE  00  B8
2000:0110  3B  00  50  E8  15  19  FE  76-E0  B8  20  00  50  C4  76  06
2000:0120  26
```

Each line displays 16 bytes. There is a hyphen between the eighth and ninth bytes.

The address range can also be given in the following format:

```
-D 0100 L 50
```

The above command will display 50 (hex) bytes beginning from the memory location DS:0100.

To see the contents of the memory locations of other segments, the command is given as follows:

```
-D CS:0100  0150
```

or

```
-D CS:0100  L  50
```

or

```
-1584:0100  L  50
```

or

```
-1800:0100  L  50,  etc.
```

If the D command is given with starting address only, the DEBUG causes a default of 80 (hex) bytes. It displays 128 bytes (80 hex) starting from the given address. The command **D 0100** will display 128 bytes starting from the memory location DS:0100.

```
-D 0100
2000:0100  E0  23  C0  7E  2C  3D  FE  00-7E  0C  C7  46  E0  FE  00  B8
2000:0110  3B  00  50  E8  15  19  FF  76-E0  B8  20  00  50  C4  76  06
2000:0120  26  FF  74  02  26  FF  34  9A-0E  00  47  2B  83  C4  08  EB
2000:0130  12  83  7E  E0  00  74  07  B8-3C  00  50  E8  ED  18  C7  46
2000:0140  E0  00  00  C4  76  0E  26  8B-04  26  FF  04  8B  F0  D1  E6
2000:0150  D1  E6  C4  5E  06  26  8B  07-26  8B  57  02  C4  7E  0A  8B
2000:0160  DE  26  89  01  26  89  51  02-C4  76  06  26  8B  1C  26  8B
2000:0170  44  02  03  5E  E0  26  89  1C-26  89  44  02  26  FF  04  8E
```

If D command is given without any address, the DEBUG will display 128 bytes after the last display.

5.2.7 Enter Command, E

The E command is used to enter data or machine codes. Its default register is the DS. It provides the following two options:

(a) To enter data or machine codes sequentially.
(b) To replace data or machine codes of certain memory locations.

The general format to enter sequential data or machine codes is

E address list

Suppose data are to be entered in DS segment starting from the offset address 0100. The command will be as

```
-E  0100
```

After writing the above command, data are entered in the same line giving space between adjacent data as shown below:

```
-E  0100  56  35  89  78  94
-
```

After entering the desired data Enter key is pressed. Now the DEBUG will show its prompt '-' in the next line. If data are to be entered in the next line also 'E address' command is to be given again. If only one digit of any data is typed, it is taken as a single digit data. Computer puts zero in the place of most significant position.

During data entry 24 bytes of data can be entered in a single line. Thereafter an equal (=) sign will come in the next line. Also a *bip* sound is heard. To get DEBUG prompt the return (Enter) key has to be pressed. If data entry is to be done in the next line also the command 'E address' has to be given again.

To Replace Data The command to replace data given is as follows:

-E address

Suppose we want to replace data in segment DS at offset 0100. The command to be given for this purpose is

```
-E  0100
```

This will show the contents of the memory location DS:0100 in the next line as

```
2000:0100  12.
```

2000 is the initial setting for DS, and it comes by default. 12 is the content of the memory location 2000:0100. If this data is to be changed enter the new data 26 as shown below:

```
2000:0100  12.26
```

If data of the next memory location is also to be changed, the space bar is to be pressed. It will show the content of the next memory location shown below:

```
2000:0100  12.26  85.
```

85 is the content of the memory location 0101. The new data 37 is now entered as shown:

```
2000:0100  12.26  85.37
```

In this way data replacement can be proceeded. The maximum number of bytes that can be entered in a line is 8. After replacing the desired number of data, enter key is pressed, then the debug command appears in the next line. If data replacement is continued up to the end of the line, the next line with current memory address comes automatically.

Use of Hyphen Key While replacing data if you decide to go back to the preceding byte position press hyphen key. A new line will be started. It will show the address and the content of previous byte. An example is:

```
-E 0100
2000:0100  12.35  85.32  13.42
```

Now press hyphen after the entry of 42 as shown above.

```
or 2000:0100  12.35  85.32  13
```

Press hyphen before entering 42 as shown above a new line will be started as shown:

```
2000:0101  32.
```

Now you can enter the desired data instead of 32 in the memory address 0101.

The hyphen key does not work in sequential data entry.

While replacing data one can go to the back position using backspace key in the current byte. One cannot go to the preceding byte position by pressing backspace key. On the other hand in sequential entry one can go back to the preceding byte position using backspace key.

To Enter Machine Codes Machine codes (instruction codes) are entered in the CS segment. Suppose the starting offset is 0100. The command is given as follows:

```
-E CS:0100
```

Now machine codes (in hex) are entered in the same line as

```
-E CS:0100  B8  12  00  BB  53  12  CC
```

Now using 'U address range' command, the corresponding mnemonics along with machine codes can be seen.

To Replace Machine Codes To replace machine codes the same technique is used which has been used for replacing data. The command will be as follows:

```
-E CS:0100
```

The above command will show the contents of the memory location CS:0100 in the next line:

```
1584:0100  B8.
```

B8 is the present machine code in the memory location 1584:0100. To change it, write the new code after the decimal point in the above line.

The command can also be given as:

```
-E 1800:0100  for sequential entry.
-E 1600:0100  for code replacement.
```

In place of 1584 any other starting address may also be used.

To make changes in the preceding byte position while replacing machine codes you can use hyphen key.

5.2.8 Fill Command, F

This command is used to fill the specified range of memory locations with the values given in a list. The default segment register is the DS. The general format is

F address range list

An example is

```
-F 0100 0104 45 46 43 08 09
-
```

The above values from 45 to 09 will be filled in the memory locations DS:0100 0104. This can be checked using D command.

```
-D 0100 0104
2000:0100 45 46 43 08 09
-
```

2000 is the initially set value of DS.

The F command can also be given in the following format:

```
-F 0100 L 05 45 46 43 08 09
```

The above command fills 5 given values starting from the memory location DS:0100.

If the values are to be filled in the CS segment, the command is given as follows:

```
-F CS:0100 0106 B8 12 00 BB 53 12 CC
or -F CS:0100 L 07 B8 12 00 BB 53 12 CC
```

The command can also be given in the following forms:

```
-F 1800:0100 0105 1 2 3 4 5 6
```

The entry can be checked as

```
-D 1800:0100 0105
1800:0100 01 02 03 04 05 06
```

The command can also be given as

```
-F 1800:0100 L 06 01 02 03 04 05 06
```

If the number of data in the list is less than the number of bytes in the address range, the same list is used repeatedly until all bytes in the range are filled.

Example

```
-F 0100 010B 22 33 44 55 66
-D 0100 010B
2000:0100 22 33 44 55 66 22 33 44 55 66 22 33
```

If the number of data in the list is more than the number of bytes in the address range, the extra data are ignored.

Example

```
-F 0100 0104 22 33 44 55 66 77 88 99
-D 0100 0104
2000:0100 22 33 44 55 66
```

5.2.9 Move Command, M

The M command copies (moves) the block of data from one memory area into another. The default register is the DS. The general format is

M range address

An example of move command is

```
-M 0100 0105 0110
cr -M 0100 L 06 0110
```

This command copies data from DS:0100 to DS:0105 into the address beginning from DS:0110 to DS:0115.

```
-M 0100 0105 0103
```

It is a case of overlapping. In such a case data are moved without any loss. The technique is to move data first from DS:0105 to DS:0108, then DS:0104 to DS:0107 and so on until it moves DS:0100 to DS:0103.

To move data in CS segment command is given as

```
-M CS:0100 0105 CS:0110
```

To move data from one segment to another, commands can be given:

```
-M CS:0100 0105 DS:0100
```

Commands can also be given in the following format:

```
-M 1566:0100 0105 2000:0100
```

5.2.10 Search Command, S

The search command is used to search the specified memory range for the specified list of bytes. The default register is the DS. The general format is

S range list

The list may contain one or more bytes. If the list contains only one byte, all addresses of the byte in the specified range are displayed. If the

list contains more than one byte, only the first addresses of the byte string are returned.

To Search a Byte To search a byte in a specified range the command may be given as follows:

```
S  0100  0105  02
```

Having received this command DEBUG searches the data, 02 in the memory range DS:0100 0105, and displays its address as follows:

```
2000:0105
```

This display means that 02 is at the memory location 2000:0105. Using D command the contents of the memory locations DS:0100 0105 were seen. They were as follows

```
-D  0100  0105
2000:0100  01  00  1F  03  E2  02
```

The search command can also be given in the following formats

```
S0100  L  06  02
S  CS:0100  0105  05
S  CS:0100  L  06  05
```

If the given byte is at more than one addresses, all addresses are displayed. DS:0100 0105 contains 01 02 02 05 07 02. The S command will display as follows:

```
-S  0100  0105  02
2000:0101
2000:0102
2000:0105
```

To Search a String of Bytes in the Specified Memory Range When S command is given to search a string (or group) of bytes within specified memory range, it displays only the first address of the string.

Example

(i) Suppose memory 2000:0100 contains 2 3 5 2 3 5 2 3 5 2 3 5
Search command is given to search the string of bytes 2, 3, 5 as follows:

```
-S  0100  010A  2  3  5
```

It displays:

```
2000:0100
2000:0103
2000:0106
2000:0109
```

These are starting addresses of the group of bytes 2, 3 & 5.

(ii) Data are DS:0100 05 2 6 3 8 9 2 6 3 10 15
Search command is given to search the group of bytes 2 6 3 as

```
-S 0100 010A 2 6 3
```

It displays as

```
2000:0101
2000:0106
```

5.2.11 To Save a File

Before saving a file, name is assigned to the file by N (name) command. Its format is

-N filename.COM

.

The name of the drive can also be given with N command as

-N A :filename.COM

.

A is for floppy drive, C for hard disk. If drive name is not given in the above command, the file is saved on hard disk.

After assigning a name to a file it can be saved using write command, W. Its format is

-W address

Before giving write command the number of bytes to be saved is to be given in the register BX:CX. The default register is the CS. If address is not given with the W command, the file is saved beginning from CS:0100.

For example,

```
-N BR1.COM
```
BR1 is the name of a file

```
-R BX
BX 0000
:
-R CX
CX 0000
: 000A
```
,number of bytes of the file is 0A.

```
-W 0200
```

'Writing 000A bytes' will be shown on the screen.

.

The file BR1 will be saved beginning from CS:0200.

5.2.12 To Load a File

Before loading a file give name of the file using N command. Thereafter use L command to load a file.

For example,

```
-N A:B1.COM  B1 is the name of a file
-L
```

The L command loads file into the memory beginning from CS:0100 and sets registers BX:CX to the number of bytes loaded.

5.2.13 Summary of DEBUG Commands

A (Assemble) converts mnemonics into machine codes. The machine codes are directly stored in the memory. The default address is CS:0100. Formats are:

A ; assembles beginning from CS:0100

A Address assembles starting from the given address

C (Compare) compares the contents of two specified blocks of memory. The default register is the DS. The general format is

C Range Address

Example

```
-C  0100  010A  0200
-
```

The above command compares the contents of memory locations DS:0100-DS:010A with the contents of memory locations starting from DS:0200. When contents of the two blocks are same, the debug prompt is shown in the next line.

When the contents of the two blocks of memory are not same, the addresses where contents are different are displayed.

Example

```
-C  0100  010A  0200
or -C  0100  L  010A  0200
2200:0105  06  15  2200:0205
2000:0107  08  13  2200:0207
```

In this case content at DS:0105 was 06, whereas at DS:0205 was 15. This has been displayed in a line. Similarly the content at 2200:0107 and 2200:0207 were 08 and 13 respectively. This has been displayed above in the last line.

D (Display or dump) displays the contents of specified memory locations. The default register is the DS:IP. Formats are:

D address range

or **D address**

or **D**

Examples are:

-D 0100 0120	displays the contents of the memory locations from DS:0100 to DS:0120.
D 0100 L 50	displays 50 (hex) bytes starting from the memory location DS:0100.
D 0100	displays 128 (80 hex) bytes starting from DS:0100.
D	displays 128 bytes after the last display.
D CS:0100 0120	displays memory contents from CS:0100 to CS:0120.
D 1600:0100 0150	displays from 1600:0100 to 1600:0150.

E (Enter) To enter data or machine codes. Default register is the DS:IP. Formats are:

E address list

E address

Examples are:

-E 0100 56 35 89 78 94	Enter data starting from DS:0100
-E 0100	
2000:0100 12	Replace data of DS:0100
-E CS:0100 B8 12 00 BB 53 12 CC	Enter machine codes starting from CS:0100.
E CS:0100	
1584:0100 B8.	Replace code of 1584:0100
-E 1800:0100	Codes or data for sequential entry.
-E 1800:0100	For code or data replacement.

F (Fill) fills a range of memory locations with the values in the list. The default register is the DS. Formats are:

F address range list

G (Go) Executes program. Provides break-point. Default register is the CS:IP. Formats are:

G = address

Example are

-G = 0100	Executes program from CS:0100.
-G	Executes program from CS:IP.
G address	Provides break-point.
-G 0109	Executes program from CS:IP to CS:0109.

H (Hexadecimal) shows the sum and difference of two hexadecimal numbers. The maximum length of a number is of four hex digits.

(i) -H 8 5
(Result) 000D 0003
(sum) (difference)

(ii) -H 8 9
0011 FFFF (2's complement of 1)

I (Input). Inputs and displays one byte from a port. Format are:

I port address

L (Load) It is used to load a file or program. Its default register is CS. Before loading C file its name is given using N command. Then L command is given to load the file. After loading a file the DEBUG sets registers BX:CX to the number of bytes loaded.

M (Move) Copies (moves) the block of data from one memory area into another. The default register is the DS. The general format is

M range address

Examples:

-M 0100 0105 0110	Copies bytes from DS:0100 0105 into DS:0110 0115.
-M 0100 0105 0103	Copies bytes from DS:0100-DS:0105 into the address beginning from DS:0103. This is a case of overlapping.
-M CS:0100 0105 CS:0110	It is an example of moving data in CS segment.
-M CS:0100 0105 DS:0100	This is an example of moving data from CS segment to DS segment.
-M 1566:0100 0105 2000:0100	Command can also be given in this format.

N (Name) It is used to name a program or file to be read or written onto disk. The format is

-N filename.COM

When drive name is not given in the command, the file will be saved on the hard disk.

To save a file on floppy disk the command is

-N A :filename.COM

A is the name of the floppy disk drive, and C is that of the hard disk.

After assigning a name the file is saved or read using L (load) or W (write) command.

O (Output) Sends a byte to a port. Format is

O port address byte

Q (Quit) It is used to exit DEBUG. Terminates the DEBUG utility and returns to the MS-DOS without saving the file you are currently working with. The format is

Q

R (Register) Displays the contents of one or more CPU registers, and the next instruction. Format is

-R register name

If register name is not given, it displays the contents of all registers and flags.

S (Search) Searches the specified memory range for the specified list of bytes. The default register is the DS. Format is

S range list

Examples:

-S 0100 0105 02	Searches 02 in the memory range DS:0100 0105. Displays the memory locations where 02 is stored.
or -S 0100 L 06 02	
-S CS:0100 0105 05	Searches in CS segment.
-S CS:0100 L 06 05	Searches in CS segment.
-S 0100 010A 2 6 3	Searches the string of bytes 2, 6 and 3 in the memory range DS:0100 010A. Displays only the first address of string.

T (Trace) Executes a program in a single-step mode. After executing one instruction it displays the contents of all registers and flags. The default register is the CS:IP. The format is

T = address

Examples are:

-T = 0100	Executes instruction at the address CS:0100.
-T	Executes instruction at the address CS:IP
-T = 0100 02	Executes two instructions in single-step mode. After executing each instruction, it shows registers & flags.

U (Unassemble) Unassembles machine code of specified memory range. Displays machine codes and corresponding mnemonics with address. The default address is CS:IP. General format is

U address range or **U address**

Examples are:

-U 0100 0112	Unassembles from CS:0100 to CS:0112.
-U 0100	Unassembles 32 bytes starting from CS:0100.
-U	Unassembles 32 bytes starting from CS:IP, or Unassembles 32 bytes since last U, if any.

W (Write) It is used to save a file or program. Default register is the CS. Format is

W address

If address is not given the file is saved starting from CS:0100. Before saving a file its name is to be given using N command. The number of bytes to be saved is to be given in BX:CX. See example in the Section 5.2.11.

5.3 ASSEMBLER

An Assembler is a program which translates assembly language program into machine language program or object program. A **self-assembler** or **resident assembler** is an assembler which runs on a computer for which it produces object codes. A **cross-assembler** is an assembler which runs on a computer other than that for which it produces object codes. Some microprocessor-based systems are not provided with an assembler. For such a system cross-assembler is required. The programmer writes an assembly language program and obtains machine codes using other computer provided with a cross-assembler. Machine codes obtained from the cross-assembler are then loaded into the memory of the microprocessor-based system and the program is executed. Also, when a designer does not have an assembler for a microprocessor-based system being developed, a cross-assembler is required.

A **macro-assembler** is an assembler which allows user to define sequence of instructions as macro.

A **meta assembler** is an assembler which can handle different instruction sets. The programmer must define a particular instruction set which is to be used.

Disassembler A disassembler generates an assembly language program corresponding to an object program. Its role is complementary to an assembler. Sometimes an object program is available, and the programmer wants to understand the program. In such a situation the programmer needs a software (disassembler) to convert the object program to an assembly language program.

One-Pass Assembler An assembler which goes through an assembly language program only once and produces its object codes is known as one-pass assembler. Such an assembler must have some means to take forward references into consideration. In assembly language programs labels are used to point forward references. The one-pass assembler must have some ways to assign addresses to the labels.

Two-Pass Assembler An assembler which goes through an assembly language program twice to produce object program (machine code program) is known as two-pass assembler. Such an assembler doesn't

face difficulty with forward references. One-pass assembler is faster as it goes through an assembly language program only once. Its disadvantage is that it doesn't provide as many features as a two-pass assembler. Two-pass assemblers are commonly used.

A two-pass assembler first reads the source program instructions (instructions or pseudo instructions or data) line by line in the first pass. It collects and defines all the symbols. It prepares an address symbol table to handle labels. If any line has label, it is stored in the address symbol table together with the following information:

(i) line number which contains the label
(ii) the relative address of the label

To compute the line number and the relative address, the assembler uses two counters: one to count line number and the other to count the memory location (abbreviated as LC) to indicate relative address of an instruction. LC stands for location counter. The pseudo instruction ORG initialises the location counter to the value of the first location usually zero. The content of the location counter holds the address of the memory location assigned to an instruction.

In the second-pass, instructions are translated using lookup tables. The assembler uses following four tables:

(i) Pseudo instruction table
(ii) MRI table
(iii) Non MRI table
(iv) Address symbol table

The pseudo instruction table contains the pseudo instructions of the assembler. The MRI table contains memory-reference instructions. The non MRI table contains register-reference and input-output instructions. The address symbol table is prepared during the first pass of the assembly process.

The assembler also detects syntax errors in the source program. In addition to the task of translation, the assembler also has some other important features viz, it allows to use pseudo instructions (assembler directives), macros, and allows to assign names to constants, variables and addresses.

5.3.1 Assembler Directives (Pseudo Instructions)

An assembly language program contains two types of statements: instructions and directives. The instructions are translated into machine codes whereas directives are not translated into machine codes. The directives are statements to give direction to the assembler to perform the task of assembly process. They control the organization of the program and process of assembly. They indicate how an operand or section of a program is to be processed by the assembler. The assembler

supports directives for data definition, segment organization, procedure, macro definition, etc.

The Microsoft MACRO assembler, MASM, has provision to select the assembler for one of the Intel microprocessors. If the programmer doesn't indicate the option for a microprocessor, the assembler for 8086/8088 is selected by default. If the programmer gives directives .486, the assembler selects the instruction set of 80486 microprocessor in the real mode. If the programmer gives directives. 486P, the assembler selects 80486 protected mode instruction set. The Table 5.2 shows the directives to select the instruction set of Intel microprocessors.

Table 5.2 Directives to Select Intel Microprocessors

Directive	*Function*
.286	Selects the 80286 instruction set in real mode
.286P	Selects the 80286 protected mode instruction set
.386	Selects the 80386 instruction set in real mode
.386P	Selects the 80386 protected mode instruction set
.486	Selects the 80486 instruction set in real mode
.486P	Selects the 80486 protected mode instruction set
.586	Selects the Pentium instruction set in real mode
.586P	Selects the Pentium protected mode instruction set
.287	Selects the 80287 math coprocessor
.387	Selects the 80387 math coprocessor

Symbols, Variables and Constants

The programmer should select meaningful names for variables to improve readability and to facilitate program maintenance. The following characters are used for symbols:

Upper and lower case alphabets: A to Z, and a to z

Digits: 0 to 9

Special Characters: _(under score), @, $, ?

The digits are not used as a first character of a variable name. Variables can have any of the following characters;

A to Z, a to z, _ (underscore), @, 0 to 9

$ and ? are not used in variable name because they are used for other purposes in assembly language programming.

The name of a variable must begin with a letter (alphabet) or an underscore. There is no distinction between upper and lower case letters. The length of a variable name depends on the assembler. Most 8086 assemblers allow to use names and labels up to 32 characters. The letters B, D and H are written at the end of a binary, decimal and hexadecimal number respectively. The assembler converts a decimal and

hexadecimal number to their binary equivalent so that the number can be loaded into memory. However, a number with no identification letter is treated as a decimal number. A hexadecimal number whose first digit is between A to F, must begin with 0, otherwise it will be treated as a symbol. The hexadecimal number C53A should be written as 0C3AH.

5.3.2 Description of important directives

DB (Define Byte) The directive DB defines a byte type variable. It directs the assembler to reserve one byte of memory and initialize that byte with the specified value. It can define single or multiple variables. Its general format is

Name of variable DB initialization value(s)

Examples

(i) `TEMPERATURE DB 0`

The above directive directs assembler to reserve one byte of memory for a variable named TEMPERATURE and initialize with value zero.

(ii) `DEFLECTION DB ?`

This directive directs assembler to reserve one byte of memory for a variable DEFLECTION. The question mark ? in the data definition tells assembler that its value is not known, and hence it is not initialized.

(iii) `ARRAY DB 54,. 39, 50, 80, 25`

The above directive reserves 5 bytes of consecutive memory locations for variable named ARRAY. The memory locations are initialized with the values 54, 39, 50, 80 and 25.

(iv) `LOADS DB ?, ?, ?, ?, ?`

The above directive reserves 5 bytes of consecutive memory locations for variable named LOADS without initialization.

(v) `BOYSNAMES DB 100 DUP(?)`
`BOYS_NAMES DB 100 DUP(?)`

The above directives will reserve 100 bytes of consecutive memory locations for the variable named BOYSNAMES without initialization. DUP stands for duplicate. As spaces cannot be used within a name to separate words, underscore can be used as shown above in BOYS_NAMES.

(vi) `ARRAY DB 3, 2, 4, 5 DUP (55), 67, 96`

The above directive reserves 10 bytes of consecutive memory locations and initializes with the values 3, 2, 4, 55, 55, 55, 55, 55, 67 and 96. 5 DUP(55) means that duplicate 55 five times.

(vii) `ARRAY DB 4 DUP (3 DUP (5), 2, 8, 6)`

The above directive will reserve 24 consecutive memory bytes. The series 5, 5, 5, 2, 8, 6 is duplicated four times.

(viii) BOY1 DB 'MOHAN'
or BOY1 DB "MOHAN"

The above directive defines a variable BOY1 and reserves 5 bytes of consecutive memory locations and initializes each location with the ASCII code of the corresponding character. The ASCII code for M is put in the first memory location, the ASCII code for O is put in the 2nd memory location, and so on. Either letters or numbers can be placed in the single quotation or double quotation marks.

DW (Define Word) The directive DW defines a word type variable. It reserves two bytes of consecutive memory locations and initializes those bytes with the specified values. It can define a single or multiple word variables. Its general format is as fallows:

Name of variable DW Initialization value

Examples

(i) MULTIPLIER DW 46D3H

This directive reserves two bytes of consecutive memory locations and initializes them with the value 46D3H.

(ii) PRODUCT DW 2 DUP(0)

The above directive reserves 2 words (4 bytes) of consecutive memory location and tells assembler to initialize the 4 bytes with all zeros.

(iii) NUMBERS DW 1354, 2563, 9096

The above directive will reserve 6 bytes of consecutive memory locations and initialize them with the values 1354, 2563 and 9096.

DD (Define Double Word) This directive defines a double word (4 bytes) variable. It reserves 4 bytes of consecutive memory locations and initializes these memory locations with the specified values. It can define single or multiple double word variables.

Examples

(i) NUMBER DD 12152025

The above directive reserves four bytes of consecutive memory locations and initializes them with 12, 15, 20 and 25.

(ii) NUMBERS DD 5 DUP(0)

The above directive will reserve 20 (5 times 4) bytes of consecutive memory locations and initialize them with zeros.

DQ (Define Quad Word) This directive defines a quad word (4 words) type variable. It reserves 8 bytes of consecutive memory locations and initializes them with the specified values. It can define single or multiple quad word variables.

Examples

(i) NUMBER DQ 0

The above directive reserves 8 bytes of consecutive memory locations and initializes them with zeros.

(ii) `NUMBERS DQ 10 DUP(0)`

The above directive will reserve 80 (10 x 8) bytes of memory locations and initialize them with zeros.

DT (Define Ten Bytes) The directive DT defines ten bytes variable. It reserves 10 bytes of consecutive memory locations and initializes them with the specified values. It can define single or multiple ten bytes variables. DT type variable are useful where math coprocessor instructions are executed.

Examples

(i) `NUM1 DT 0`

The above directive reserves 10 bytes of consecutive memory locations and initializes them with zeros.

(ii) `NUMBERS DT 100 DUP(0)`

The above directive will reserve 1000 (100 times 10) bytes of consecutive memory locations and initialize them with zeros.

EXTRN (External) This directive tells the assembler that names or labels following the directive are in some other assembly module.

Examples

(i) `EXTERN MULTIPLIER : WORD`

The above directive declares the variable MULTIPLIER as external. In case a variable is declared external, the type of variable is also specified. In this case WORD indicates the type of the variable MULTIPLIER.

(ii) `EXTERN WATER_LEVEL : FAR`

In the above directive WATER_LEVEL is a procedure which is external. In case of procedure, it must be specified that whether it is NEAR or FAR. In case of label also FAR or NEAR has to be specified. The procedures must be declared PUBLIC in the module where they exists, and are specified EXTERN in the module where they are being referred.

PUBLIC A large program may contain a number of program modules. Each module is assembled, tested and debugged separately. The PUBLIC directive informs the assembler that the defined name or label can be accessed from other program modules. A variable or label is declared PUBLIC in the module in which it is defined. If a variable or label is used in an instruction of another program module, it must be specified external using EXTRN directive. It helps linker to link the object code files together to form a complete program.

General Form:

PUBLIC Variable 1, ..., Variable N

Example

```
PUBLIC  MULTIPLICAND,  MULTIPLIER
```

GLOBAL This directive can be used in place of PUBLIC or in place of EXTRN directive.

If we write GLOBAL MULTIPLIER in the current program module, it declares the variable MULTIPLIER public so that it can be accessed from other program modules.

If we write GLOBAL MULTIPLIER : WORD in another program module, it tells the assembler that MULTIPLIER is an external variable and it is a variable of word type.

SEGMENT The directive SEGMENT indicates the beginning of a logical segment. The name of the segment is written before the directive SEGMENT.

General Form:

Name of the segment SEGMENT [WORD/PUBLIC]

The type specifier WORD tells assembler that the segment is to be located at the next available word (even) address. In absence of the specifier WORD, the segment will be located at the next available paragraph (16-byte size) address which may cause wastage up to 15 bytes of memory. The type specifier PUBLIC tells the assembler that this segment may be combined with other segments having the same name from the other assembly modules when modules are linked together.

Examples

(i) `DATA_SEG  SEGMENT  WORD`

In the above directive DATA_SEG is the name given to a segment.

(ii) `CODE_SEG  SEGMENT  PUBLIC`

ENDS The directive ENDS informs the assembler the end of the segment. The directive ENDS is used with the SEGMENT directive to enclose a logical segment containing data or instructions.

Example

```
CODE_SEG  SEGMENT              ; Start of the code segment
          ..
          ;                    ; Instruction statements
          ..
CODE_SEG  ENDS                 ; End of the segment
                                 named CODE_SEG
```

ENDP The ENDP directive is used to assemble the end of a procedure. This directive together with the procedure directive PROC is used to enclose a procedure. To indicate the type of a procedure, NEAR or FAR follows PROC. If it is not specified, the assembler assumes NEAR.

Example

```
TEMPERATURE_CONTROL   PROC          ; Start of procedure
          ..
          :                         ; Instruction statements
          ..
TEMPERATURE_CONTROL   ENDP          ; End of procedure
```

END This directive is used after the last statement of a program to inform the assembler that this is the end of a program module. The carriage return is pressed after the END directive.

ASSUME This directive tells the assembler the name of a logical segment, which is to be used for a specified segment.

Example

```
CODE_SEG   SEGMENT                  ; start of CODE_SEGMENT
ASSUME  CS  :  CODE_SEG
```

The above directive tells the assembler that the instructions for a program are in the logical segment named CODE_SEG.

Example

```
DATA_SEG   SEGMENT                  ; start of DATA_SEG
ASSUME  DS:DATA_SEG
```

The above directive tells the assembler that for any program instruction which refers to the data segment, the logical segment named DATA_SEG is to be used.

EQU This directive is used to assign name to some value. Whenever the assembler finds the assigned name in the program, it replaces the assigned name with the value.

Example

```
OVEN_TEMPERATURE   EQU  04H.
```

If we write the above directive in the beginning of a program, and later in the program we write MOV AL, OVEN_TEMPERATURE. While writing the code the assembler will treat this instruction as if we have written MOV AL, 04H. If any value is written many times in a program, it is better to assign it a name and write its value in the beginning of the program using EQU directive. If during analysis the value is to be changed, it should be done in the beginning.

ORG (Originate) The ORG directive tells the assembler to assign addresses to data items or instructions in a program.

Example

```
ORG  01DAH
```

The above directive tells the assembler that the address 01DAH is to be assigned to the next data item or instruction. Instructions and data

following the ORG directive are assigned addresses sequentially starting from the address specified by ORG.

A "$" indicates the current value of the address. The directive ORG $ + 30 directs the assembler to increment the current address by 30. This type of directive might be used in a data segment to leave certain bytes of space for future use.

SRUCT or STRUC This directive is used to define the start of a data structure. It declares the data type which is a collection of primary data types: DB, DW and DD. The structure declaration allows the user to define a variable which has more than one data type.

General Form:

```
Structure Name      STRUC
                    .
                    .
                    .   Sequence of DB, DW and DD directives
                    .
                    .
Structure Name      ENDs
```

RECORD This directive is used to define a bit pattern within a byte or a word.

General Form:

Record Name RECORD Field specification 1,.....Field specification N

Where each field specification is of the form:

Field Name : Length

Thus, the RECORD directive breaks a byte into several fields. Each field can be assigned a name which can be used as data in the assembly language programming.

PTR It is an operator. It points the type of memory access (BYTE/WORD/DWARD)

Example

(i) MOV BYTE PTR [BX], 58H

The above instruction will move a BYTE to the memory location specified by the register BX. Suppose the register BX contains memory address 0301H. The data 58H will move to the memory location 0301H.

(ii) MOV WORD PTR [BX], 5489H

The above instruction will move a WORD to the memory locations specified by register BX. 89H will move to [BX] and 54 to [BX+1]. Suppose BX contains 0301H. The data 89H will move to the memory location 0301H and 54 to the memory location 0302H.

The PTR operator can also be used to override the type of a specified variable.

(iii) SPEED DW 1230H

The instruction MOV AL, BYTE PTR SPEED, will move the lower byte of the variable SPEED, i.e. 30H to register AL.

OFFSET It is an operator which tells the assembler to determine the offset of a variable from the starting address of a segment. It is used to load the offset of variable into a register.

Example

```
MOV AX, OFFSET TEMPERATURE
```

Before the above instruction the variable TEMPERATURE has already been defined in a DATA SEGMENT. The assembler will now compute the OFFSET for the variable TEMPERATURE from the starting address of the DATA segment in which it has been defined. Then the computed OFFSET will be moved to AX.

LENGTH It is an operator which tells the assembler to determine the number of elements in a specified variable such as a string or an array.

Example

```
MOV CX, LENGTH ARRAY1
```

The above instruction will determine the number of elements of the ARRAY1 and move it to the register CX. If the ARRAY1 has been declared as an array of bytes, LENGTH will give the number of bytes in the array. If the ARRAY 1 is declared as an array of words, LENGTH gives the number of words in the array.

SIZE It gives the number of bytes allocated to the data item, whereas LENGTH gives the number of elements in a data item.

The list, given in Table 5.3 summarises some directives and operators which have not been explained above.

Table 5.3

Directive or Operator	*Function*
STARTUP	Indicates the start of the program when using program modules
STACK	Starts a stack segment
STRUC	Defines the start of a data structure
USE16	Directs the assembler to use 16-bit instruction mode and data sizes for the 80386 - Pentium Pro
USE32	Directs the assembler to use 32-bit instruction mode and data sizes for the 80386 - Pentium Pro
RECORD	It is used to define bit pattern within a byte or a word
EVEN	Align on the even memory address

Contd.

Table 5.3 Contd.

TYPE	It is pointer. It is used to tell the assembler to determine the type of a specified variable
INCLUDE	It tells the assembler to insert a block of source code from the named file into the current source module
SHORT	It tells the assembler that only one byte displacement is required to code a jump instruction. Normally, two bytes are required for displacement. Hence, this directive saves one memory location.

5.3.3 Procedure for Entering and Executing ALP

An assembly language program (ALP) may be entered and saved in any IBM compatible PC using any ASCII text editor. The file should be saved with an extension, file name. ASM. The MS-Assembler 6.1 has inbuilt editor/debug/execute modes in programmer workbench mode, PWB. EXE.

Step to be followed are:

1. Enter assembly language program using any ASCII text editor or inbuilt text editor in MASM 6.1.
2. Select the 'Built All' function in PWB. If there is no error in the entered program, it will ask for different options (a) Run (b) Debug (c) Cancel (d) View Result. If there is an error, go to step 1 by selecting 'View Result' and see the error and correct the ALP accordingly. Repeat the step 2, till no error massage is displayed.
3. To execute the program, select RUN mode. The ALP may be developed with a subroutine to display the result on VDU. The results given by the computer are in binary. Before sending the results to VDU, they must be converted to ASCII codes.

   If subroutine to display the results has not been written by the programmer the result can be seen in the Debug mode.
4. To execute the program in single step mode, select 'Debug'. While executing program in the single step mode, examine registers and memory in different windows.

For details see Microsoft's MASM manuals (i) Reference and (ii) Environment and Tools.

Two examples of ALP to run on assembler are given below:

Example

To find largest number from a given array in memory

```
SSEG          SEGMENT
                        DB          32 DUP ("Stack----")
SSEG          ENDS
DSEG          SEGMENT
ARRAY-COUNT             DW          0004
DATA-ARRAY              DW          9452H, 7386H, 3567H, 9586H
```

```
DATA-LARGE      DW      0000
DSEG    ENDS
CSEG    SEGMENT                 'code'
ASSUME  CS: CSEG, DS: DSEG,     SS: SSEG
MAIN    PROC    NEAR
PUSH    DS                              ; initialise before main
                                          program returns to OS
MOV     AX,00
PUSH    AX
MOV     AX, DSEG
MOV     DS, AX
MOV     SI,00
MOV     SI,00
MOV     CX, ARRAY-COUNT                 ; load CX with array
                                          count
MOV     AX, DATA-ARRAY                  ; initialise AX with 1st
                                          data from array
BACK:   INC     SI
        INC     SI                      ; set SI for next data in
                                          array
        CMP     AX, DATA-ARRAY[SI]      ; compare 2nd number
                                          with 1st number
        JNC  GO
        MOV     AX, DATA-ARRAY[SI]      ; if 2nd number larger
                                          update AX
GO:     LOOP    BACK
        MOV     [DATA-LARG], AX         ; Save largest number
        MOV     AH, 4CH                 ; return code for OS
        INT     21H
        RET
MAIN    ENDP
CSEG    ENDS
        END     MAIN
```

Examine the results in AX or the memory location following the memory locations specified for data. For the given data array the largest number is 9586 hex. The results are examined after the execution of the program using DEBUG program of the assembler.

Example

Sum of a series of 16-bit number. Result 32-bit

```
SSEG    SEGMENT
                DB      32  DUP  ("Stack----")
SSEG    ENDS
```

```
DSEG        SEGMENT
COUNT               DW      0005
DATA                DW      2605H, 5C3BH, 2853H, 2182H
SUM-DATA    DW              0000, 0000
DSEG        ENDS
CSEG        SEGMENT         'CODE'
ASSUME      CS: CSEG, DS:DSEG, SS: SSEG
MAIN        PROC    NEAR
PUSH        DS                          ; initialise before main program to return to OS.
MOV         AX, 00
PUSH        AX
MOV         AX, DSEG
MOV         DS,AX
MOV         SI,00
MOV         CX, COUNT                   ; load CX with count
MOV         AX, 0000                    ; initialise AX with 0000
MOV         BX, 0000                    ; initialise BX with 0000
L2:  ADD    AX, DATA [SI]               ; 1st data be added to AX
     JAE    L1
     INC    BX
L1:  INC    SI
     Loop   L2
     MOV    [SUM-DATA], AX
     MOV    [SUM-DATA +2], BX
     MOV    AH, 4CH
     INT    21H                         ; return code for OS
     RET
MAIN ENDP
CSEG ENDS
     END    MAIN
```

Examine result in AX and BX or in the memory location following the memory loction specified for data.

Review Questions

5.1 What is DEBUG ? Discuss its important commands.

5.2 What is U command ? Explain what happens when following commands are given:

(i) U [address range]
(ii) U address
(iii) U ∟n, n is a hexadecimal number
(iv) U without any address

5.3 What are the commands for the following functions:
(i) To execute a program.
(ii) To display the contents of a register.
(iii) To display the contents of all registers.
(iv) To run a program in single-step mode.
(v) To display contents of memory locations.

5.4 What is an assembler ? Is it an electronic device ? Discuss one-pass and two-pass assemblers.

5.5 Explain the following:
(i) Macroassembler
(ii) Disassembler
(iii) Meta assembler

5.6 What are assembler directives?

5.7 Discuss the function of the following directives:
(i) SEGMENT
(ii) GLOBOL, PUBLIC
(iii) ASSUME
(iv) END, ENDS and ENDP
(v) ORG
(vi) EQU
(vii) EXTRN
(viii) DB, DW, DD, DQ and DT

5.8 Discuss the function of the following operators:
(i) PTR
(ii) OFFSET
(iii) LENGTH
(iv) SIZE