

Experiment 11

11 Accessing Video Memory

Introduction

This experiment introduces the use of the VGA controller and BIOS INT 10H functions to access video memory using the different graphics modes.

You will be provided with some routines that use the video modes. You should understand these routines before inserting them properly in your programs.

Objectives

1. Use of the 640x480 16-color graphics display mode.
2. Use mode 12H to divide the screen into a 53 line by 80 characters per line to display blocks of colors.
3. Display text on the 640x480 16-color graphics display without changing the background color.

11.1 Text Mode

In DOS mode, the videotext memory starts at address location **B800:0000** through **B800:FFFF** and contains ASCII data and attributes for display. In text mode, the following functions are used to display data on the screen.

Function 01H and 02H/06: Used to read/display one character on the screen.

Function 09H/0AH: Used to display/read a string.

These functions have already been seen in previous experiments.

11.2 Graphics Mode

11.2.1 Video Adapters

The display on the monitor is controlled by a circuit known as the **video adapter**. This circuit, which is usually an add-in card, has two basic units:

- a *display memory* (also called a video buffer or video RAM) and
- a *video controller*.

The display memory stores the information to be displayed. Although it is physically located in the video adapter, it is still part of the processor address space and may be manipulated by both normal 80x86 instructions or through the video controller. The display memory starts at physical address **A0000H** or above depending on the particular video adapter. The video controller translates data into an image on the screen.

11.2.2 Video Modes

The IBM PC provides two types of displays and associated adapters.

- a. The monochrome adapter (MDA) is used to display black and white (or green) text characters.
- b. The color/graphics adapters (CGA, VGA, MCGA, EGA, SVGA, EVGA, XVGA etc.) may operate in two modes: text or graphics.

In the alphanumeric mode (text mode), 80 columns by 25 rows, or 40 columns by 25 rows, color character displays can be generated. In the graphics mode, the screen may be viewed as consisting of a rectangular grid pattern consisting of dots or **pixels**. A picture can be displayed by specifying the color of each pixel on the screen. Depending on the kind of adapter present, a program can select text or graphics mode. Each mode is identified by a *video mode number* as shown in the following table.

Mode	Type	Rows	Cols	Resolution	Colors	MDA	CGA	EGA	MCGA	VGA
0	Text	25	40	320x200	16		ì	ì	ì	ì
1	Text	25	40	320x200	16		ì	ì	ì	ì
2	Text	25	80	640x200	16		ì	ì	ì	ì
3	Text	25	80	640x200	16		ì	ì	ì	ì
4	Graph	25	40	320x200	4		ì	ì	ì	ì
5	Graph	25	40	320x200	4		ì	ì	ì	ì
6	Graph	25	80	640x200	2		ì	ì	ì	ì
7	Text	25	80	720x350	Mono	ì		ì		ì

Table 11.1: Video Modes

Depending on the kind of adapter present, a program can select text or graphics mode. Each mode is identified by a video mode number as shown in the following table.

11.2.3 The VGA Mode

The 640x480 16-color graphics display mode uses memory location A000:0000 through A000:FFFF to access graphics data. In order to display 16 colors with a resolution of 640x 480 a memory greater than 64K bytes is required. Because 16 colors require 4 bits, and the resolution is 640 x 480 (i.e. 307,200 pixels), the memory system requires 640 x 480 x 4 (i.e. 1,228,800 bits) or 153,600 bytes of video memory in this display mode.

To allow access to such as amount of memory, mode 12H display is designed to be accessed in bit planes. A bit plane is a linear section of memory that contains one of the four bits to display the 16 colors. Each bit plane requires 307,200 bits of memory, stored in 38,400 bytes of memory. The 64K bytes at segment A000H are enough to only address a single bit plane at a time. The bit plane is addressed at memory locations A000:0000 through A000:95FF. In a 640x480 display, location A000:0000

represents the upper leftmost 8 pixels, and location A000:95FF represents the lower rightmost 8 pixels.

There are four planes, or banks of memory, that overlap this address range to represent the four bits or color for each pixel (

Figure **11. 1**). To change the color of one pixel on the video display four bits need to be changed, one in each bit plane. The color codes used for a standard VGA display are shown in Table 11.2. If all 4-bit planes are cleared, black is the pixel color.

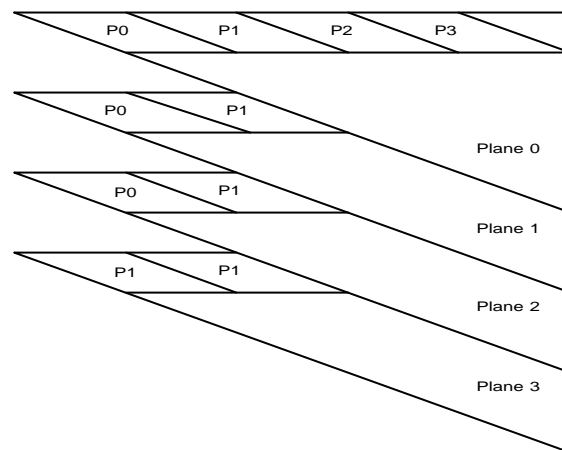


Figure 11. 1: The four bit-planes of the 640x480, 16-color VGA display

11.3 Accessing the Video Memory

Access to video memory in mode 12H is accomplished through the following steps:

Step 1: Read the byte of memory to be changed, to load the bit plane information into the video card.

Step 2: Select and address a single pixel (bit) through the graphics address register (GAR) and bit mask register (BMR). This is accomplished by sending an 8 out to I/O port 03CEH, which represents the GAR.

Steps 1 and 2 are done through the following set of instructions:

```
MOV DX, 03CEH      ; Select VGA address card
MOV AL, 08         ; Index of 8
OUT DX, AL        ; Select Index 8
```

Step 3: Load AL with the bits to be changed (a one bit represents a pixel to be changed), and send this out to the Bit Mask Register (BMR), or I/O port 03CFH.

```

MOV DX, 03CFH      ; Select BMR
MOV AL, 80H        ; Place mask in AL
OUT DX, AL         ; Select leftmost bit using 80H

```

Step 4: Set all mask bits to 1's (1111 or 0FH) in the Map Mask Register (MMR) at sequencer offset 2, and write color 0 to the VGA card (black) to the address containing the pixel, to clear the old color from the pixel.

Mask bits select the bit planes to be changed. If all are selected and a color 0 is written, all four-bit planes are cleared to zero. To do so, use the following code:

```

MOV DX, 03C4H      ; Select VGA sequencer register
MOV AL, 02         ; Index of 2
OUT DX, AL         ; Select Index 2
MOV DX, 03C5H     ; Address MMR
MOV AL, 0FH        ; Mask to 1111 binary
OUT DX, AL

```

Step 5: Send the desired color number to the MMR and write an FFH to the video memory. This places a logic one in only the selected bit planes.

To write a new color to a pixel on the screen, use the following instructions:

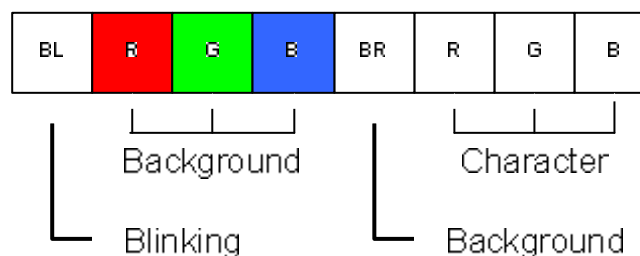
```

MOV AL, Color      ; Choose color; e.g. 03 for cyan
OUT DX, AL         ; Select color
; Next write an FFH to the selected video memory location

```

Register	Meaning	Address
GAR	Graphics Address Register	03CEH
BMR	Bit Mask Register	03CFH
MMR	Map Mask Register	03C4H to access 03C5H to select bit planes

Table 11. 2: Registers used in Video Mode



Code				Color
br	R	G	B	
0	0	0	0	Black
0	0	0	1	Blue
0	0	1	0	Green
0	0	1	1	Cyan
0	1	0	0	Red
0	1	0	1	Magenta
0	1	1	0	Brown
0	1	1	1	White
1	0	0	0	Grey
1	0	0	1	Bright Blue
1	0	1	0	Bright Green
1	0	1	1	Bright Cyan
1	1	0	0	Bright Red
1	1	0	1	Bright Magenta
1	1	1	0	Yellow
1	1	1	1	Bright White

Table 11.3: Colors Available to VGA, Mode 12H

11.4 Direct Video Access in Text Mode

The characters seen on the video monitor correspond directly to ASCII bytes stored in the video RAM. Thus to display a character, by direct video access, one need only place the ASCII code for that character into the correct video RAM location.

Example: The following program fills a screen with A's by direct video access. It uses the default text mode 3

```

,STACK 200
.CODE
.STARTUP
    MOV AX , 0B800H
    MOV DS , AX
    MOV CX , 2000           ; 2000 words
    MOV DI , 0
FILL_PAGE: MOV WORD PTR [DI], 7041h ; black A on white
    ADD DI , 2
    LOOP FILL_PAGE
    MOV AH , 08H           ; wait for a keystroke
    INT 21H

.EXIT
END

```

The formula for calculating a video memory offset address, in video page 0, given a screen row and column coordinate pair is:

$$\begin{aligned}\text{Character offset} &= (\text{row\#} * 80 + \text{column\#}) * 2 \\ &= (\text{row\#} * (64 + 16) + \text{column\#}) * 2\end{aligned}$$

Using the above formula the following procedure calculates an 80 * 25 text-mode memory address from a pair of row and column coordinates, contained in DH and DL respectively:

CALC_ADDRESS PROC

**; input: DH = row number (0 - 24) , DL = column number (0 - 79) ,
VIDEO_SEG a constant which contains ; either B000H or B800H
; output: ES:DI contains the required segment : offset address**

```

PUSH AX
MOV AX , VIDEO_SEG
MOV ES , AX
MOV AH , 0
MOV AL , DH ; AX := row#
SHL AX , 1 ; AX := row# * 2
SHL AX , 1 ; AX := row# * 4
SHL AX , 1 ; AX := row# * 8
SHL AX , 1 ; AX := row# * 16
MOV DI , AX ; DI := row# * 16
SHL AX , 1 ; AX := row# * 32
SHL AX , 1 ; AX := row# * 64
ADD DI , AX ; DI := row# * 80
MOV AH , 0
MOV AL , DL ; AX := column#
ADD DI , AX ; DI := row# * 80 + column#
SHL DI , 1 ; DI := ( row# * 80 + column# ) * 2
POP AX
RET
CALC_ADDRESS ENDP

```

Thus, for example, to display a yellow blinking T on a green background at row 6 and column 37, by direct video access, use :

```

MOV DH , 6 ; row#6
MOV DL , 37 ; column#37
CALL CALC_ADDRESS
MOV AH , 10101110B ; attribute: yellow on green
MOV AL , 'T'
STOSW

```

Note: The effect of STOSW is:

```
MOV ES:[DI] , AL
```

```
MOV ES:[DI + 1], AH
```

11.5 Bios Video Functions

Another way of accessing video memory is through **INT 10H**. This method is recommended for most applications, since it frees the user from the burden of calculating video memory addresses. The following are most functions used with INT 10H, these allow most useful video tasks. Note that INT 10H preserves only the BX, CX, DX, and the segment registers

11.5.1 Accessing the Video Memory

Before accessing video, make sure that you save the current video mode so that you can restore it once your program is finished. This can be done using the following sequence of instructions: (INT 10H)

```
MOV AH, 0FH ; Get current video mode
INT 10H
PUSH AX ; Save Video mode in AL and Number of columns AH
...
POP AX ; Restore Video mode AL and Number of columns AH
MOV AH, 00
INT 10H
```

11.5.2 Select Video Mode

```
MOV AH, 00
MOV AL, VIDEO_MODE
INT 10H
```

Function 00 automatically clears the screen. To preserve the screen while changing the mode set the most significant bit of AL to 1.

```
MOV AH, 00
MOV AL, VIDEO_MODE
OR AL, 80H
INT 10H
```

11.5.3 Get Current Video Mode

```
MOV AH, 0FH
INT 10H
PUSH AX ; Or MOV Old_Video_Mode, AX
```

11.5.4 Restore Previous Video Mode

```
POP AX ; Or MOV AX, Old_Video_Mode
MOV AH, 00H
```

INT 10H**11.5.5 Cursor Manipulation**

If the row and column numbers are in Hexadecimal they can directly be assigned to the DX register. The cursor positioning on the current video page is independent of the other video pages.

1. Set Cursor Position

To set the cursor at a given position use:

```
MOV AH, 02H
MOV BH, Current_Video_Page_Number ;Usually 0
MOV DH, Row_Number
MOV DL, Column_Number
INT 10H
```

2. Get Cursor Position

To get the cursor position use:

```
MOV AH, 03H
MOV BH, Current_Video_Page_Number ; Usually 0
INT 10H
MOV Save_Cursor, CX
MOV Current_Row, DH
MOV Current_Column, DL
```

3. Set Cursor Size

The cursor is displayed using starting and ending scan lines. In Mono mode the cursor uses 12 lines (0,1,2, .. 0BH,0CH), whereas in color mode it uses 8 lines (0,1, ...,6,7).

```
MOV AH, 01H
MOV CH, Start_Scan_Line#
MOV CL, End_Scan_Line#
INT 10H
```

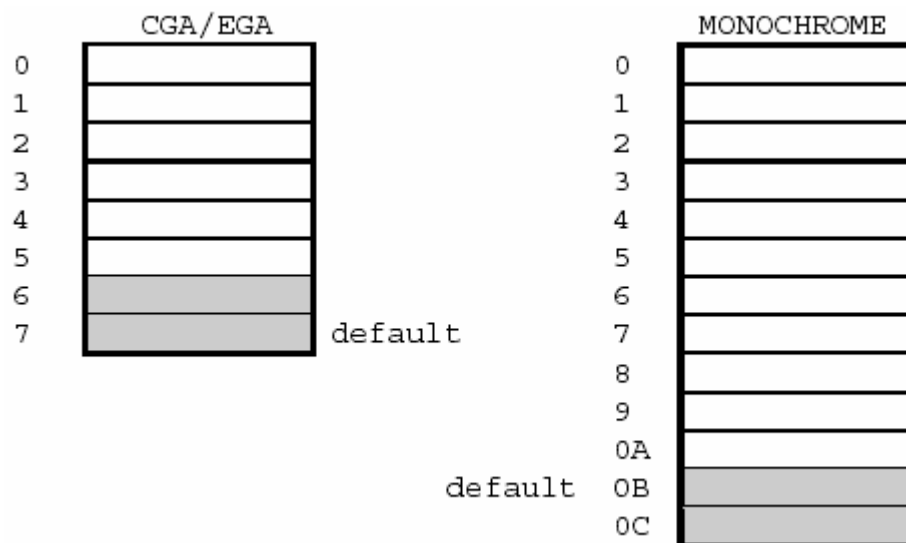


Figure 11. 3: Cursor Size**Example:**

- a. To set the cursor to its maximum size in color mode

```
MOV AH, 01H
MOV CX, 0007H
INT 10H
```

- b. To set the cursor to its maximum size in monochrome mode

```
MOV AH, 01H
MOV CX, 000CH
INT 10H
```

4. Write Pixel

To put a pixel on the screen

```
MOV AH, 0CH
INT 10H
```

5. Restore the current cursor size:

```
MOV AH, 01H
MOV CX, Cursor_Size ; Cursor_Size previously saved
INT 10H
```

6. Make the Cursor Invisible

Set the starting scan line to an illegal value by setting bit 5 in CH to 1.

```
MOV AH, 01H
OR CH, 00100000B ; Or MOV CX, 2000H
INT 10H
```

Another way of hiding the cursor is to place it in the undisplayed portion of the video page, e.g. row #25 column # 0.

```
MOV DH, 25 ;Row number
MOV DL, 00 ;Column number
MOV AH, 02H
MOV BH, 00 ;Video page # 0
INT 10H
```

11.5.6 Set Border Color

To set the border to a given color use the following sequence:

```
MOV AH, 0BH
MOV BH, 00H
```

```
MOV BL, 04H  
INT 10H
```

11.6 Lab Work

11.6.1 Pre-Lab

- 1- Write two Macros: one to get the current video mode, and the other restore the video mode.
- 2- Write and run programs 11.1 and 11.2. Write your programs using macros and procedures.
- 3- Prepare all programs in this experiment by writing them using macros and procedures.

11.6.2 Lab Work

- 1- Show programs 11.1 and 11.2 to your lab instructor.
- 2- Write and run programs 11.3 and 11.4.
- 3- Write a program that displays the time on the top right hand corner of the display. Use INT 11H function 02, which inputs the column and row numbers in DL and DH respectively, and Video page (usually 0) in BH.

11.6.3 Lab Assignment

Rewrite the program that displays the time on the screen using graphics mode only. Review the part that shows how to display text in video mode.

Title 'Program 11-1'

; A program that blanks the test mode screen and makes it red.
 ; It then displays the message This is a test line. before
 ; returning to DOS.
 ;

```
.MODEL SMALL
.DATA
MES DB 'This is a test line.$'
.CODE
.STARTUP
MOV AX,0B800H ;address text segment
MOV ES,AX
CLD ;select increment
MOV DI,0 ;address text offset
MOV AH,40H ;attribute black on red
MOV AL,20H ;character is space
MOV CX,25*80 ;set count
REP STOSW ;clear screen and change attributes

MOV AH,2 ;home cursor
MOV BH,0 ;page 0
MOV DX,0 ;row 0, char 0
INT 10H

MOV DX,OFFSET MES ;display "This is a test line."
MOV AH,9
INT 21H
.EXIT
.END
```

Title 'Program 11-2'

;a program that displays all of 256 colors available to the
 ;320 x 200 video display mode (13H)
 ;***uses***
 ;the BAND procedure to display 64 colors at a time in a band
 ;on the display.
 ;

```
.MODEL TINY
.CODE
.STARTUP
MOV AX,13H ;select mode 13H
INT 10H

MOV AX,0A000H ;address segment A000 with ES
MOV ES,AX
CLD ;select increment
MOV DI,0 ;address offset 0000

MOV AL,0 ;load starting test color of 00H
CALL BAND ;display one band of 64 colors

MOV AL,64 ;load starting color of 40H
CALL BAND ;display one band of 64 colors
```

```

MOV AL,128      ;load starting color of 80H
CALL BAND      ;display one band of 64 colors

MOV AL,192      ;load starting color of C0H
CALL BAND      ;display one band of 64 colors

MOV AH,1        ;wait for any key
INT  21H

MOV AX,3        ;switch back to DOS video mode
INT  10H
.EXIT

;
;the BAND procedure displays a color band of 64 colors
;***input parameter***
;AL = starting color number
;ES = A000H
;DI = starting offset address for display
;
BAND PROC NEAR
    MOV BH,40      ;load line count
BAND1:
    PUSH AX        ;save starting color
    MOV CX,64      ;load color across line count
BAND2:
    MOV BL,5       ;load times color is displayed
BAND3:
    STOSB          ;store color
    DEC BL
    JNZ BAND3      ;repeat 5 times
    INC AL         ;change to next color
    LOOP BAND2     ;repeat for 64 colors
    POP AX         ;restore starting color
    DEC BH
    JNZ BAND1      ;repeat for 40 lines
    ADD DI,320*10  ;skip 10 lines
    RET
BAND ENDP
END

```

Title 'Program 11-3'

;a program that displays all the possible brightness levels of the
;color red for the 320 x 200, 256-color mode (13H)

```

;
.MODEL TINY
.CODE
.STARTUP

        MOV  AX,13H           ;switch to mode 13H
        INT  10H

        MOV  AX,0A000H      ;address segment A000 with ES
        MOV  ES,AX
        CLD                  ;select increment

        MOV  CH,0           ;green value
        MOV  CL,0           ;blue value
        MOV  DH,0           ;red value
        MOV  BX,80H         ;color register number 80H
        MOV  AX,1010H       ;change palette color function
        MOV  DL,64          ;count to change colors 80H to BFH
PROG1:
        INT  10H           ;change a color value
        INC  DH             ;next color of red
        INC  BX             ;next color palette register
        DEC  DL
        JNZ  PROG1         ;repeat for 64 colors

        MOV  DI,0           ;address offset 0000
        MOV  AL,80H         ;starting color number
        CALL BAND           ;display 64 colors

        MOV  AH,1           ;wait for any key
        INT  21H

        MOV  AX,3           ;switch back to DOS video mode
        INT  10H

.EXIT

;the BAND procedure displays a color band of 64 colors
;***input parameter***
;AL = starting color number
;ES = A000H
;DI = starting offset address for display
;
BAND PROC NEAR

        MOV  BH,40          ;line count of 40
BAND1:
        PUSH AX              ;save starting color number
        MOV  CX,64          ;color count of 64
BAND2:
        MOV  BL,5           ;load times color is displayed
BAND3:
        STOSB                ;store color

```

```

    DEC  BL
    JNZ  BAND3          ;repeat 5 times
    INC  AL             ;get next color number
    LOOP BAND2         ;repeat for all 64 colors
    POP  AX             ;restore original color number
    DEC  BH
    JNZ  BAND1         ;repeat for 40 raster lines
    ADD  DI,320*10     ;skip 10 raster lines
    RET

BAND ENDP
END

```

Title 'Program 11-4'

;a program that displays a green box on the video screen using
;video mode 13H.

```

;
.MODEL TINY
.CODE
.STARTUP
    CLD                ;select auto-increment

    MOV  AX,13H        ;select mode 13H
    INT  10H           ;this also clears the screen

    MOV  AL,2          ;use color 02H (green)
    MOV  CX,100        ;starting column number
    MOV  SI,10         ;starting row number
    MOV  BP,75         ;size
    CALL BOX           ;display box

    MOV  AH,1          ;wait for any key
    INT  21H

    MOV  AX,3          ;switch to DOS video mode
    INT  10H

.EXIT

;the BOX procedure displays a box on the mode 13H display.
;***input parameters***
;AL = color number (0-255)
;CX = starting column number (0-319)
;SI = starting row number (0-199)
;BP = size of box
;
BOX  PROC NEAR
    MOV  BX,0A000H    ;address segment A000 with ES
    MOV  ES,BX
    PUSH AX           ;save color
    MOV  AX,320       ;find starting PEL
    MUL  SI
    MOV  DI,AX        ;address start of BOX
    ADD  DI,CX
    POP  AX

```

```

        PUSH  DI           ;save starting offset address
        MOV   CX,BP       ;save size in BP
BOX1:  REP   STOSB        ;draw top line
        MOV   CX,BP
        SUB   CX,2        ;adjust CX

BOX2:  POP    DI
        ADD   DI,320      ;address next row
        PUSH  DI
        STOSB             ;draw PEL
        ADD   DI,BP
        SUB   DI,2
        STOSB             ;draw PEL
        LOOP  BOX2

        POP   DI
        ADD   DI,320      ;address last row
        MOV   CX,BP
        REP   STOSB
        RET

BOX    ENDP
      END

```

Title 'Program 11-5'

;a program that displays a short cyan line that is 10 Pixels wide
;with a red dot below and to the right of the cyan line.

```
.MODEL TINY
```

```
.CODE
```

```
.STARTUP
```

```

        MOV   AX,0A000H   ;address video RAM at segment A000
        MOV   DS,AX
        CLD               ;select increment

        MOV   AX,12H      ;set mode to 12H
        INT   10H         ;and clear screen

        MOV   CX,10       ;set dot count to 10
        MOV   BX,10       ;row address
        MOV   SI,100      ;column address
        MOV   DL,3        ;color 3 (cyan)
MAIN1:  CALL  DOT         ;plot 10 dots
        INC   SI           ;display one dot
        LOOP  MAIN1       ;repeat 10 times

        MOV   BX,40       ;row address
        MOV   SI,200      ;column address
        MOV   DL,4        ;color 4 (red)
        CALL  DOT         ;display one red dot

        MOV   AH,1        ;wait for key
        INT   21H
        MOV   AX,0003
        INT   10H         ;return to DOS video mode

.EXIT

```


;the DOT procedure displays one dot or PEL on the video display.

;BX = row address (0 to 479)

;SI = column address (0 to 639)

;DL = color (0 to 15)

;

```

DOT PROC NEAR
  PUSH CX
  PUSH DX           ;save color
  MOV AX,80         ;find row address byte
  MUL BX
  MOV DI,AX         ;save it
  MOV AX,SI         ;find column address byte
  MOV DH,8
  DIV DH
  MOV CL,AH        ;get shift count
  MOV AH,0
  ADD DI,AX        ;form address of PEL byte

  MOV AL,80H
  SHR AL,CL        ;find bit in bit mask register
  PUSH AX          ;save bit mask

  MOV DX,3CEH       ;graphics address register
  MOV AL,8         ;select bit mask register
  OUT DX,AL

  MOV DX,3CFH       ;bit mask register
  POP AX           ;get bit mask
  OUT DX,AL

  MOV DX,3C4H       ;sequence address register
  MOV AL,2         ;select map mask register
  OUT DX,AL

  MOV DX,3C5H       ;map mask register
  MOV AL,0FH       ;enable all planes
  OUT DX,AL

  MOV AL,[DI]       ;must read first
  MOV BYTE PTR [DI],0 ;clear old color
  POP AX           ;get color from stack
  PUSH AX
  OUT DX,AL
  MOV BYTE PTR [DI],0FFH;write memory

  POP DX           ;restore registers
  POP CX
  RET

```

DOT ENDP

END

Title 'Program 11-6'

;a program that display a cyan bar across the top of a white
;screen.

```

;
.MODEL TINY
.CODE
.STARTUP
MOV AX,0A000H ;address video RAM at segment A000
MOV DS,AX
CLD ;select increment

MOV AX,12H ;set mode to 12H
INT 10H ;and clear screen

MOV CX,80 ;block count
MOV BX,0 ;row address
MOV SI,0 ;column address
MOV DL,3 ;color 3 (cyan)
MAIN1: ;plot 80 blocks
CALL BLOCK ;display a block
INC SI ;address next column
LOOP MAIN1 ;repeat 80 times

MOV BX,1 ;row address
MOV DL,7 ;color 7 (white)
MOV DH,52 ;row count
MAIN2:
MOV SI,0 ;column address
MOV CX,80 ;column count
MAIN3:
CALL BLOCK ;display a block
INC SI ;address next column
LOOP MAIN3 ;repeat 80 times
INC BX ;increment row address
DEC DH
JNZ MAIN2 ;repeat 52 times

MOV AH,1 ;wait for key
INT 21H

MOV AX,3
INT 10H ;return to DOS video mode
.EXIT

```

;The BLOCK procedure displays one block that is 8 pixels
;wide by 9 pixels high.

;BX = row address (0 to 52)
;SI = column address (0 to 79)
;DL = block color (0 to 15)

```

;
BLOCK PROC NEAR

```

```

    PUSH CX
    PUSH DX ;save color

```

```

MOV DX,3CEH           ;graphics address register
MOV AL,8              ;select bit mask register
OUT DX,AL
MOV DX,3CFH          ;bit mask register
MOV AL,0FFH          ;enable all 8 bits
OUT DX,AL

MOV DX,3C4H          ;sequence address register
MOV AL,2              ;select map mask register
OUT DX,AL

MOV AX,80*9           ;find row address byte
MUL BX
MOV DI,AX             ;save it
ADD DI,SI             ;form address of PEL byte

MOV CX,9              ;byte count
MOV DX,3C5H          ;map mask register
POP AX                ;get color
PUSH AX
MOV AH,AL
BLOCK1:
MOV AL,0FH           ;enable all planes
OUT DX,AL
MOV AL,[DI]          ;must read first
MOV BYTE PTR [DI],0 ;clear old color
MOV AL,AH
OUT DX,AL
MOV BYTE PTR [DI],0FFH ;write memory
ADD DI,80
LOOP BLOCK1

POP DX
POP CX
RET

BLOCK ENDP
END

```

Title 'Program 11-7'

;program that display a bright red B at row 0, column 0, and a
;cyan A at row 5, column 20.

```

.MODEL TINY
.CODE
.STARTUP
MOV AX,0A000H       ;address video RAM at segment A000
MOV DS,AX
CLD                 ;select increment

MOV AX,12H          ;set mode to 12H
INT 10H             ;and clear screen

MOV AL,'A'          ;display 'A'

```

```

MOV DL,3      ;cyan
MOV BX,5      ;row 5
MOV SI,20     ;column 0
CALL CHAR     ;display cyan 'A'

MOV AL,'B'    ;display 'B'
MOV DL,12     ;bright red
MOV BX,0      ;row 0
MOV SI,0      ;column 0
CALL CHAR     ;display bright red 'B'

MOV AH,1      ;wait for key
INT 21H

MOV AX,3
INT 10H       ;return to DOS video mode
.EXIT

;
;The CHAR procedure displays a character (8 x 8) on the
;mode 12H display without changing the background color.
;AL = ASCII code
;DL = color (0 to 15)
;BX = row (0 to 52)
;SI = column (0 to 79)
;
CHAR PROC NEAR

    PUSH CX
    PUSH DX
    PUSH BX    ;save row address
    PUSH AX    ;save ASCII
    MOV AX,1130H ;get 8 x 8 set
    MOV BH,3
    INT 10H    ;segment is in ES
    POP AX     ;get ASCII code
    MOV AH,0
    SHL AX,1   ;multiply by 8
    SHL AX,1
    SHL AX,1
    ADD BP,AX  ;index character in ROM
    POP BX     ;get row address
    MOV AX,80*9 ;find row address
    MUL BX
    MOV DI,AX
    ADD DI,SI  ;add in column address
    MOV CX,8  ;set count to 8 rows

C1:
    MOV DX,3CEH ;address bit mask register
    MOV AL,8    ;load index 8
    MOV AH,ES:[BP] ;get character row
    INC BP     ;point to next row
    OUT DX,AX  ;modify bit mask register
    MOV DX,3C4H ;address map mask register
    MOV AX,0F02H
    OUT DX,AX  ;select all planes

```

```

INC    DX
MOV    AL,[DI]    ;read data
MOV    BYTE PTR [DI],0 ;write black
POP    AX        ;get color
PUSH   AX
OUT    DX,AL     ;write color
MOV    BYTE PTR [DI],0FFH
ADD    DI,80     ;address next raster row
LOOP   C1       ;repeat 8 times

POP    DX
POP    CX
RET

```

```

CHAR  ENDP
      END

```

Title 'Program 11-8'

;a program that displays two test lines of text on a cyan graphics
;background screen.

```

;
.MODEL SMALL
.DATA
MES1 DB 'This is test line 1.',0
MES2 DB 'This is test line 2.',0

.CODE
.STARTUP
MOV  AX,0A000H    ;address video RAM
MOV  DS,AX
CLD              ;select increment

MOV  AX,12H      ;set mode to 12H
INT  10H        ;and clear screen

MOV  DL,3        ;color cyan
MOV  DH,53       ;row counter
MOV  BX,0        ;row 0
MAIN1:
MOV  CX,80       ;column counter
MOV  SI,0        ;column 0
MAIN2:
CALL BLOCK      ;display a cyan block
INC  SI         ;address next column
LOOP MAIN2     ;repeat 80 times
INC  BX        ;address next row
DEC  DH        ;decrement row counter
JNZ  MAIN1     ;repeat for 53 rows

MOV  AX,@DATA   ;address data segment
MOV  ES,AX      ;with ES

MOV  DL,9       ;bright blue text

```

```

MOV  BX,5           ;row 5
MOV  SI,0           ;column 0
MOV  DI,OFFSET MES1 ;address MES1
CALL LINE          ;display bright blue MES1

MOV  DL,12         ;bright red
MOV  BX,15         ;row 15
MOV  SI,0           ;column 0
MOV  DI,OFFSET MES2 ;address MES2
CALL LINE          ;display bright red MES2

MOV  AH,1          ;wait for key
INT  21H

MOV  AX,3
INT  10H           ;return to DOS video mode
.EXIT

;
;The line procedure displays the line of text addressed by ES:DI
;DL = color of text (0 to 15).
;The text must be stored as a null string
;BX = row
;SI = column
;
LINE PROC NEAR

MOV  AL,ES:[DI]   ;get character
OR   AL,AL        ;test for null
JZ   LINE1        ;if null
PUSH ES           ;save registers
PUSH DI
PUSH SI
CALL CHAR         ;display characters
POP  SI           ;restore registers
POP  DI
POP  ES
INC  SI           ;address next column
INC  DI           ;address next character
JMP  LINE         ;repeat until null
LINE1:
RET

LINE ENDP
;
;The CHAR procedure displays a character (8 x 8) on the
;mode 12H display without changing the background color.
;AL = ASCII code
;DL = color (0 to 15)
;BX = row (0 to 52)
;SI = column (0 to 79)
;
CHAR PROC NEAR

PUSH CX
PUSH DX

```

```

    PUSH BX          ;save row address
    PUSH AX          ;save ASCII
    MOV AX,1130H     ;get 8 x 8 set
    MOV BH,3
    INT 10H
    POP AX           ;get ASCII code
    MOV AH,0
    SHL AX,1         ;multiply by 8
    SHL AX,1
    SHL AX,1
    ADD BP,AX        ;index character in ROM
    POP BX           ;get row address
    MOV AX,80*9      ;find row address
    MUL BX
    MOV DI,AX
    ADD DI,SI        ;add in column address
    MOV CX,8         ;set count to 8 rows
C1:
    MOV DX,3CEH      ;address bit mask register
    MOV AL,8         ;load index 8
    MOV AH,ES:[BP]   ;get character row
    INC BP           ;point to next row
    OUT DX,AX
    MOV DX,3C4H      ;address map mask register
    MOV AX,0F02H
    OUT DX,AX        ;select all planes
    INC DX
    MOV AL,[DI]      ;read data
    MOV BYTE PTR [DI],0 ;write black
    POP AX           ;get color
    PUSH AX
    OUT DX,AL        ;write color
    MOV BYTE PTR [DI],0FFH
    ADD DI,80        ;address next raster row
    LOOP C1          ;repeat 8 times
    POP DX
    POP CX
    RET

```

CHAR ENDP

```

;
;The BLOCK procedure displays one block that is 8 pixels
;wide by 9 pixels high.
;BX = row address (0 to 52)
;SI = column address (0 to 79)
;DL = block color (0 to 15)
;

```

```

BLOCK PROC NEAR
    PUSH CX
    PUSH DX          ;save color

    MOV DX,3CEH      ;graphics address register
    MOV AL,8         ;select bit mask register
    OUT DX,AL
    MOV DX,3CFH      ;bit mask register

```

```

MOV AL,0FFH           ;enable all 8 bits
OUT DX,AL

MOV DX,3C4H           ;sequence address register
MOV AL,2              ;select map mask register
OUT DX,AL

MOV AX,80*9           ;find row address byte
MUL BX
MOV DI,AX             ;save it
ADD DI,SI             ;form address of PEL byte

MOV CX,9              ;byte count
MOV DX,3C5H           ;map mask register
POP AX                ;get color
PUSH AX
MOV AH,AL
BLOCK1:
MOV AL,0FH           ;enable all planes
OUT DX,AL
MOV AL,[DI]          ;must read first
MOV BYTE PTR [DI],0  ;clear old color
MOV AL,AH
OUT DX,AL
MOV BYTE PTR [DI],0FFH ;write memory
ADD DI,80
LOOP BLOCK1

POP DX
POP CX
RET

BLOCK ENDP
END

```