

PDP-X Technical Memorandum # 8

Title: Small XY Display

Author(s): H. Burkhardt  
L. Seligman

Index Keys: Display  
IO  
Peripherals

Distribution

Keys: A, B, C

Obsolete: None

Revision: None

Date: July 11, 1967

## 0. Overall Description

This display is a replacement for the 34 oscilloscope display that is often sold on PDP-9 and PDP-8. The display controller can be used to drive

- a. Techtronix 503 or 564
- b. Conrac type XY scope
- c. Storage tubes as they become available

## 1. General Specifications

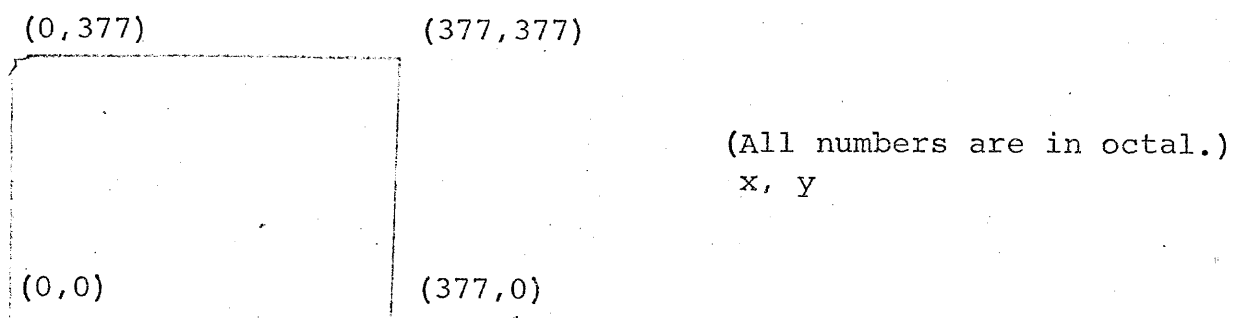
The XY display may be used for graph plotting, character plotting or other forms of non-complicated graphics. The control includes a "raster mode" to facilitate character generation as well as facilities for loading the individual X and Y axis registers and for adding data words to the individual axis registers. Four intensity levels are available to allow parts of the data being displayed to be accentuated.

The axis resolution is one part in 256, i.e., the axis registers are 8 bits in length.

### 3. Programming

The XY display is controlled by setting or changing bits in its status register by use of the IOC or IOX instructions respectively. The status register may be sensed or tested by use of the IOS or IOT instructions respectively.

The display contains two 8-bit registers, designated the X-Axis register and the Y-Axis register. These two registers define a position on the face of the display screen:

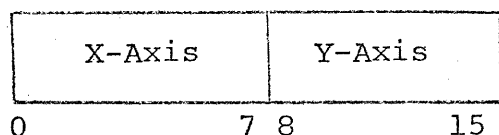


The X- and Y-Axis registers are loaded with data as indicated by the contents of the control fields in the Status Register. A point is then intensified as indicated by the contents of the BRIGHTNESS bits of the Status Register.

Data may be sent directly to the display by means of IOW instructions or through the multiplexor channel. In either case, the display will operate upon the received data and set the REQ bit in its status register when done.

### 3.1 Instructions

The display will respond to all IO instructions issued by the central processor when the DA (Device Address) field contains the address of the display. The instructions IOC, IOX may be used to alter the contents of the Status Register. The instructions IOS, IOT may be used to sense the Status Register. The IOW instruction may be used to transfer data to the display or the display may be used in a multiplexor-channel mode. The IOR instruction may be used to read back the X- and Y-Axis registers:



### 3.2 Maintenance Instructions

There are no special maintenance instructions.

### 3.3 Data Formats

Data is read by the display either one byte or two bytes at a time depending upon the mode of operation established by the contents of the Status Register. If the display requires two bytes of information, they will be transferred to the display by means of an IOW instruction or under control of the multiplexor channel. The format of this data depends upon mode:

#### 3.3.1 Point Mode

Two bytes are required in point mode if the X- and Y-CONTROL bits of the Status Register specify data operations (i.e.,

either 01 or 11). Data is read as:

X Data	Y Data
--------	--------

The Y Data is byte 1 and the X Data is byte 2.

### 3.3.2 Character Mode

Character mode requires two data bytes before REQ is set. The first data byte (the right half during an IOW instruction) is used to plot the first vertical raster and the second is used to plot the second vertical raster.

### 3.6 Status Register

The Status Register of the XY display consists of 2 bytes:

MODE	LP ENABLE	LP HIT	1	REQ	BUSY	LOW	ENABLE
8	9	10	11	12	13	14	15

SPARE FOR STORAGE TUBE	Y CONTROL	X CONTROL	BRIGHTNESS
0 1	2 3	4 5	6 7

(Note: Although the Status Register is depicted in two bytes, it may be loaded, changed, read or tested with a single command.)

**ENABLE:** The ENABLE bit connects the XY display to the interrupt system. With this bit cleared, the display may in no way affect the operation of the rest of the system,\* ENABLE is cleared by the power up/down response, by instruction and from the console.

**LOW:** The LOW bit indicates which of two possible interrupt addresses will be used by the processor when the display interrupts. In normal use, LOW = 0 indicates normal data transfer on the multiplexor channel, data being transferred each time REQ rises. When the Byte Counter over-

---

\*LP ENABLE provides the same function for the Light Pen.

flows, LOW and REQ are set, causing an interrupt at the second interrupt address.

If a light pen hit occurs and LP ENABLE is set, LOW is set and an interrupt requested at the second address.

**BUSY:** The BUSY bit indicates that the display is performing the function indicated by the other control bits of the Status Register. It may be explicitly set by an IOC or an IOX command or implicitly by an IOW command. BUSY is cleared when the display completes its operation. REQ is set by the display when BUSY is cleared.

**REQ:** The REQ bit is set whenever the displays require attention. If ENABLE is also set, an interrupt will occur. REQ may be set or cleared by explicit IOC or IOX commands and is implicitly cleared during data transfers on the multiplexor channel (except for the last transfer which sets LOW).

**DIR:** Bit 11 of the Status Register is one indicating that the display is an output device. It may be sensed but will not change.

**LP HIT:** The LP HIT bit is set if the Light Pen senses light and the LP ENABLE bit is set. When LP HIT is set, LOW is set and an interrupt requested. The program may then service the light-pen interrupt, clear LP HIT and LOW and dismiss

**LP ENABLE:** The LP ENABLE bit connects the Light Pen to the interrupt system and enables the LP HIT bit.



MODE: There are two basic data modes as controlled by the state of the mode bit:

MODE = 0; Point Mode

Data words sent to the display, either by means of IOW commands or through operation of the multiplexor channel, are operated upon depending upon the setting of the X- and Y-Control bits of the Status Register. In general, a new X, Y position is produced in the X-, Y-Axis registers, the beam is moved to the indicated position on the display face and intensified according to the setting of the intensity bits of the Status Register. When this operation has been completed, REQ is set and BUSY is cleared. More data is sent to the display depending upon whether or not it is connected to the interrupt system.

MODE = 1; Character Mode

The display reads a 2-byte data word and plots an 8 by 2 point raster. For each bit in the data word that contains a 1, the corresponding point of the raster is intensified according to the setting of the intensity bits of the Status Register. The X- and Y-Control bits of the Status Register are ignored. After the entire 8 by 2 point raster has

been plotted, the X-Axis register has been incremented by 2 and the Y-Axis register if left undisturbed. When this operation has been completed, REQ is set and Busy cleared. More data is sent to the display depending upon whether or not it is connected to the interrupt system. A full character may be plotted by displaying 6 bytes or 3 words in character mode to produce an 8x6 point raster. The data word is displayed as:

Y + 7      8      7

Y + 6      9      6

Y + 5      10      5

Y + 4      11      4

Y + 3      12      3

Y + 2      13      2

Y + 1      14      1

Y            15      0

X      X + 1

The original contents of the X - and Y-Axis registers were (X, Y). The final contents are (X + 2, Y)

**BRIGHTNESS:**

Two bits of the Status Register (6, 7) control the brightness of the points generated by operation of the display control:

00	don't intensify
01	lowest intensity
10	medium intensity
11	highest intensity

**X-CONTROL**

Two bits of the Status Register (4, 5) control the loading of the X-Axis register while in point mode (MODE=0). Data is read from the processor and the X-Axis register is updated according to:

00	Clear X-Axis Register
01	Load X-Axis Register with data byte
10	Leave X-Axis Register unchanged
11	Add data byte to old contents of X-Axis register and load the result into the X-Axis register.

After the new X- and Y-Axis values are established, the beam is moved and intensified according to the setting of the intensity bits of the Status Register. When this operation has been completed, REQ is set and BUSY cleared.

## Y-CONTROL

Two bits of the Status Register (2, 3) control the loading of the Y-Axis register while in point mode (MODE=0). These bits are interpreted in a fashion identical to the interpretation of the X-Control bits.

## 3.7 Programming Examples

Because of the inherent flexibility of the XY display, it is difficult to provide comprehensive programming examples:

## 3.7.1 Programmed Operation

Assume that the subroutine labeled SUBR calculates new X, Y coordinates in real time. Each call to SUBR places a new value of X in accumulator ACX and a new value of Y in accumulator ACY. The program merely transfers these data points to the display and recalls the subroutine:

```
; "DIS" IS THE DEVICE ADDRESS OF
; THE XY DISPLAY
```

```
BEGIN:      IOC DIS, [013430] ; SET REQ, SET BRIGHTNESS
              ; TO HIGHEST VALUE, SET
              ; X-Y CONTROL FIELDS TO
              ; LOAD, CLEAR ALL OTHER
              ; BITS
```

```

GO:  BAL SUBR          ; CALL SUBROUTINE

      STC ACX, [2*ACY + 1] ; STORE C(ACX) IN LEFT
                                ; HALF OF C(ACY)
                                ; ACCUMULATOR ACY NOW
                                ; CONTAINS A 2 BYTE
                                ; DATA WORD

WAIT: IOT DIS, [00010] ; TEST REQ FOR A ONE

      BZ          WAIT  ; IF ZERO, WAIT

      IOW DIS,  ACY    ; WRITE ACY TO DISPLAY
                                ; THIS CLEARS REQ AND
                                ; SETS BUSY

      B          GO    ; GET ANOTHER POINT

```

(Note: The octal constant in the IOC instruction could be written in binary as: 00010111 00011000.)

### 3.7.2 Character Plotting Without Display File

Assume that there is a text string in memory that is terminated by an EOT character. This string is pointed to by the contents of register TEXT. The text is to be displayed on the tube face until the contents of the register STOP become non-zero as set by the main program. The display service routine will then clear the contents of STOP and stop displaying the text string. A character table is stored in memory starting at location TABLE. This table consists of 3 entries (6 bytes) per symbol.

```
; MAIN PROGRAM STARTS DISPLAY
```

```
CLR  STOP          ; CLEAR STOP SWITCH
```

```

STA AC, TEXT          ; SET POINTER TO TEXT
                        ; BUFFER
STA AC, POINT         ; SET POINTER TO BEGINNING
                        ; OF THE TEXT STRING
IOC DIS, [13]         ; NOW - FORCE A LOW
                        ; INTERRUPT

```

```

- - - - -
- - - - -

```

; TO STOP THE TEXT BEING DISPLAYED

```

COM STOP
TST STOP
BN      -1            ; WAIT TO STOP
- - - - -

```

; TO CHANGE THE TEXT BEING DISPLAYED

```

- - - - -
STA AC, TEXT          ; LOAD NEW POINTER TO
                        ; BEGINNING OF TEXT STRING
- - - - -

```

DISPLAY INTERRUPT SERVICE ROUTINE

```

DISINT:  IOT DIS, [40] ; TEST LP HIT
          BN          PENSER ; IF SET-SERVICE LIGHT-PEN
GETCHR:  LDC AC, POINT ; NO-GET CHARACTER TO BE
                        ; DISPLAYED
          CMP AC, [15] ; TEST FOR CARRIAGE RETURN
          BZ CR        ; BRANCH IF YES
          CMP AC, [12] ; NO-TEST FOR LINE-FEED

```

```

BZ      LF          ; BRANCH IF YES
CMP AC, [04]        ; TEST FOR EOT
BZ      EOT         ; BRANCH IF YES
          ; NO-FORM BYTE POINTER
          ; TO THE SIX BYTES IN
          ; TABLE TO PLOT THIS
          ; CHARACTER

```

```

MUL AC, [6]         ; 6 BYTES/SYMBOL
ADD AC + 1, [2*TABLE] ; ADD START OF TABLE
STA AC + 1, DISINT + 1 ; LOAD CHANNEL BYTE POINTER
LDA AC, [-6]
STA AC, DISINT      ; LOAD CHANNEL BYTE COUNTER
IOC DIS, [1631]     ; CLEAR LOW, SET REQ
          ; SET MODE, SET BRIGHTNESS TO
          ; HIGHEST, SET ENABLE
PSD              ; DISMIS

```

PROCESS CARRIAGE-RETURN BY CLEARING X-AXIS REGISTER

```

CR:  IOC DIS, [20023] ; CLEAR REQ, SET ENABLE, CLEAR
          ; MODE, SET X-CONTROL TO CLEAR
          ; Y-CONTROL TO DON'T DISTURB
          ; BRIGHTNESS TO DON'T INTENSIFY
          ; SET LOW

```

```

IOW DIS, [0]        ; WRITE

```

```

PSD              ; DISMIS, DISPLAY WILL INTERRUPT WHEN DONE

```

## PROCESS LINE-FEED BY ADDING 10 TO Y-AXIS REGISTER

```

LF:      IOC DIS, [34023]      ; CLEAR REQ, SET ENABLE, CLEAR
                                           ; MODE, SET X-CONTROL TO DON'T
                                           ; DISTURB, SET Y-CONTROL TO ADD,
                                           ; BRIGHTNESS TO DON'T INTENSIFY
                                           ; SET LOW

      IOW DIS, [-12]           ; ADD -10 TO Y

      PSD                      ; DISMIS

```

## PROCESS EOT BY RESETTNG POINTER

```

EOT:     LDA AC, TEXT
          STA AC, POINT
          TST     STOP          ; TEST STOP MODE
          BZ      CONTIN        ; IF ZERO-CONTINUE
          COM     STOP          ; STOP, CLEAR STOP AND
          IOC DIS, Ø            ; CLEAR DISPLAY
          PSD                      ; DISMIS

CONTIN:  IOC DIS, [12023]      ; CLEAR REQ, SET ENABLE, CLEAR
                                           ; MODE, SET X-CONTROL TO
                                           ; LOAD, Y-CONTROL TO LOAD,
                                           ; BRIGHTNESS TO DON'T
                                           ; INTENSIFY, SET LOW
          IOW DIS, XYINIT       ; WRITE INITIAL VALUES
          PSD                      ; DISMIS

XYINIT:  Ø                      ; INITIAL VALUE OF (X, Y)

```