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THE X-Y DIGITAL PLOTTER AS AN OUTPUT UNIT FOR THE ODRA
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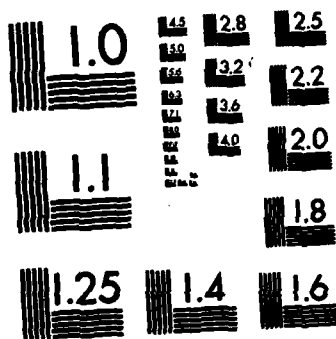
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FOR THE Odra 1325 DIGITAL COMPUTERS

by

Urszula Kreglewska, Tomasz Kreglewska, Andrzej Lewandowski



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THE X-Y DIGITAL PLOTTER AS AN OUTPUT UNIT FOR THE ODRA 1325 DIGITAL COMPUTERS

Urszula Kreglewska, M.S. (Eng.), Tomasz Kreglewski, M.A. (Eng.), Andrzej Lewandowski, Ph.D. (Eng.)

Described here is an electronics system as well as a programming system making it possible to adapt the X-Y Hewlett-Packard digital plotter as an output unit for ODRA 1300 digital computers, with the plotter working in the tape punch channel.

In the Automation Institute of the Warsaw Polytechnical University, a system has been developed and adopted for linking the type 9862 X-Y digital plotter made by Hewlett-Packard with an ODRA 1325 computer.

Innerworking between the plotter and the computer is made possible by means of a unit controlling a DT 325 perforated tape punch, together with a small system that adapts this unit for the requirements of the plotter. The DT 325 control unit operates the tape punch for the plotter depending on the positioning of an auxiliary switch.

The set of procedures directly communicating with the plotter has been written up and adopted; these procedures, after being added to the processing program, facilitate program operation of the plotter. Processing software has also been developed.

The Principle of Plotter Control

A plotter draws figures on a surface in a field described by X and Y coordinates. The coordinates are whole numbers in the range [0.9999]. The plotter pen moves to a point (XB, YB) when the unit receives values for coordinates for a new position, that is, to successive numbers XB, YB. The pen can be controlled both by lifting it or dropping it.

The X-Y digital plotter is connected with a control unit by means of a line along which TTL [transistor-transistor logic] logic signals are sent.

The data lines along which position coordinates for the plotter pen are sent are the following: A7, A6, ..., A0. The coordinates, which are four-figure numbers, are sent in BCD [binary-coded decimal] code. In order to change the plotter position, it is necessary to sample the data lines four times -- the first two computer transmissions constitute the X coordinate, and the following two the Y coordinate.

The control lines which transmit the signals that interpret the data line states are the following:

- the SYNC line, by means of which the computer signals the beginning of transmission of the data set;
- the MVR line, which defines, or whose transmission is an order for lifting or dropping the pen, or which forms a point coordinate;
- the PNC line, which defines the state of whether the pen should be raised or dropped (if the MVR line is in an appropriate configuration).

In addition to the lines described here, there are two additional ones -- they organize information exchange transmitted along the SYNC, MVR, PNC, A7, ..., A6 lines. By means of the FLAG line, the plotter sends a signal to the control unit indicating that it is ready for receiving new information. By means of the CONTROL line, the control unit signals the plotter that it can read the states of the information lines.

The innerworking of the plotter with the control unit is illustrated in Fig. 1. Once the control unit has received the FLAG ready signal, it sends the

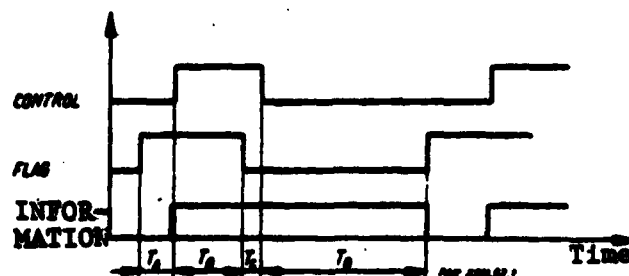


Fig. 1. The principle of X-Y digital plotter control.

information along the plotter lines; when the SYC, MVR, ... lines have been correctly sampled, that is, after time T_A , the CONTROL signal is sent to the plotter. After a time T_B , the unit is put in a busy condition and the FLAG signal is cleared, causing the control unit to clear, the CONTROL signal, after a time T_C ; The information lines are continuously sampled, because their states are analyzed throughout the entire period of plotter busy condition. When the unit makes a request connected with received information (within the time $T_C + T_D$), it changes to the ready state and once again sends the FLAG signal along the line.

The Control Unit for Interaction Between the Computer and the X-Y Digital Plotter

A block diagram of this system is shown in Fig. 2. The computer communicates with the digital plotter through a control unit consisting of the DT 325 unit as

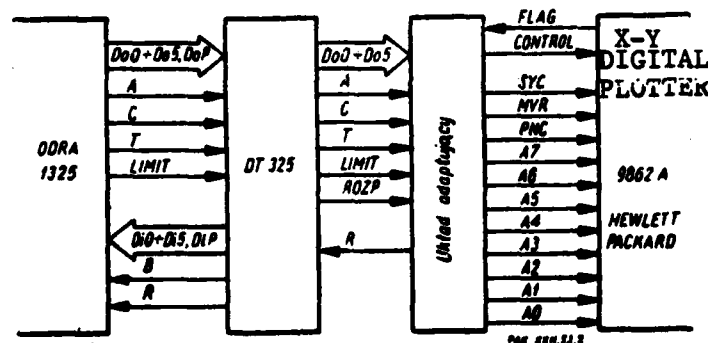


Fig. 2. Block diagram for hook-up between computer and X-Y digital plotter.

well as an adaptation device. The ODRA 1325 controls the working of this unit by means of an interface line in the same way as interworking with the perforated paper tape punch. The control unit carries out the following functions:

1. It checks the correctness of information received from the computer and marks information sent to the computer.
2. It decipheres received instructions.
3. It sends information to the computer on the possibility of carrying out an instruction.

4. It informs the computer of its own state and the state of the plotter.
5. It interrupts the computer for the purpose of providing immediate information on the following:
 - the possibility of linking up for interworking;
 - malfunctioning in the plotter;
 - termination of interworking.
6. It stores information in the memory that is to be sent to the plotter.
7. It reports readiness for receiving a following character (along line R) to the computer from its holding buffer unit.

The functions numbered above 1-5 are carried out by the DT 325 logic units. It is only the functions numbered 6 and 7 that must be carried out by means of the additional unit, and this is because of the following reasons:

1. The unit of information for the perforated paper tape punch is a six-bit character, whereas the plotter must receive in a single transmission 11-bit information, and this requires grouping the characters from the computer into two groups before sending to the plotter.
2. The character transmission frequency from the computer is a function of the rapidity of operation of the plotter, so that sending a control unit to the ODRA 1325 for a new character must be carried out in the adaptation device, which communicates directly with the plotter.

The following changes have been implemented in the DT 325 unit in connection with using it for controlling both the perforated paper tape punch as well as the digital plotter (these changes are cited on the basis of developments referred to in work [1]):

1. When the plotter is supposed to work, the START signal setting the perforated paper tape punch into operation is switched off; the START signal is transmitted to the motor control unit across the contacts of an auxiliary stabilizer

switch, which should run the plotter with the DT 325.

2. When transmitting the ready signal for receiving a new character (along line R) from the computer to the digital plotter, the signal is sent from the adaptation device. R signals from the perforated paper tape punch and the plotter are thus switched by a second pair of contacts for the kind of switch mentioned above.

3. During plotter functioning zero is input for the KD signal, which in the case of tape punch operation informs the control unit logic about the termination of the operation of the executive mechanism.

A block diagram of the adaptation device is shown in Fig. 3.

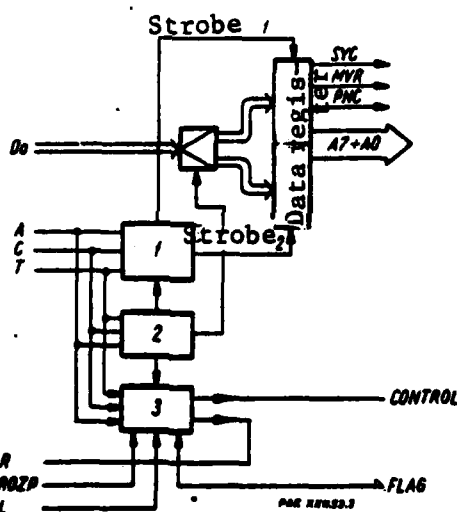


Fig. 3. Block diagram for the adaptation device: 1 - register strobing device, 2 - character counting device, 3 - control device.

This device operates on successive logic signals taken directly from the DT 325 device:

1. Signals entering from the computer:
 - Do0-Do5, 6-bit data character,
 - A address signal indicating that the computer is querying the plotter,
 - the C signal determining that there are data or an instruction on the Do0-Do5 lines,

the T time strobe,

the LIMIT signal assigning the last character of the holding buffer unit.

2. Signals originating in the DT 325 unit:

the ZER signal putting the logic units in their initial states, the ROZP pulse that arises when the control unit accepts the WRITE instruction from the computer, beginning the functioning of the logic units responsible for data transmission.

Information transmission from the computer is preceded by the WRITE instruction, which is decoded in the DT 325 unit. If it accepts this instruction, the ROZP signal arises causing the storage of the fact that the instruction WRITE has been received in the control portion of the adaptation device.

If the plotter sends the FLAG signal, the control device sends a request for a character to the computer along line R. In answer the computer sends a character which is written by means of the first strobe pulse into the first position of the shift register (data register). At the same time, the character counting device takes on the value 1. When the transmission of the first character is complete, the adaptation device immediately sends a new R signal requesting a second character. The new character is entered into the second position of the shift register. The changed condition of the character counter causes the CONTROL signal to be sent to the digital plotter, whereas the character counter takes on its initial value.

The plotter clears the FLAG signal, takes the information from the adaptation device, processes it, and if it is ready for further interaction, once again samples the FLAG line. This causes a regeneration of the R signal by the control device and a repetition of the transmission cycle computer--control unit--plotter.

Transmission termination follows from the initiative of the computer, which together with the last character, sends the termination signal L (LIMIT). The control portion of the adaptation device then takes on the same state it had before receiving the instruction WRITE.

Basic Software for the Digital Plotter

The basic software makes it possible to effectively exploit the plotter as an output unit using programs written in FORTRAN. The following system of subroutines in PLAN language is used for controlling the plotter:

PENDOWN -- using this subroutine sends the instruction "drop the pen" (two 6-bit characters) to the plotter;

PENUP -- using this subroutine causes the transmission of the instruction "lift the pen" (two 6-bit characters) to the plotter;

POINT (IX, IY) -- using this subroutine causes the transmission of eight 6-bit characters defining the shift of the plotter pen to a point with the coordinates (X, Y) defined by whole numbers (IX' IY') according to the following equations:

$$IX' = \max (0, \min (IX, 9999))$$

$$IY' = \max (0, \min (IY, 9999)).$$

Because the plotter is a piece of slow-acting peripheral equipment, it employs a system of double buffering of the information transmitted into it. This makes it possible for the plotter and the program (the assignment of new points for drawing) to run at the same time. The length of one buffer is equal to the maximum number of characters that can be sent by means of a single instruction, amounting to 128 characters. The buffer contents are sent automatically to the plotter as soon as it has been filled. In connection with this, as soon as a drawing has been completed, it is necessary to bring about the transmission of the contents of an unfilled buffer. This subroutine serves for this:

PLOTTEREND (N, nH message of n characters) $N = n \leq 40$.

The use of this program causes the transmission of buffer contents to the plotter and the suspension of the program with the writeout of the n character message on the monitor.

Before the first use of any of the mentioned subroutines in the program, it is necessary to use the following subprogram:

PLOTTER (I).

This brings about the specification of the plotter as the peripheral unit for the program, as well as establishing the values of the initial working variables.

If the time for selecting coordinates for successive points by the program is great in comparison with the time for plotting them (the plotter waits for a long time for a new batch of data), the subroutine PLOTTER with the parameter I different from zero should be used. Then each time after sending the contents of a buffer, the pen in the plotter is raised. It is dropped only at the beginning of the transmission of a new buffer content. This prevents there being any marks in the points indicating that it was necessary to wait for a new transmission. In general the time for selecting successive coordinates is sufficiently short, and in this case, the parameter I equal to zero should be used.

The Processing Software for the Plotter

The processing software consists of a set of procedures written in FORTRAN. These procedures facilitate, to a considerable degree, using the plotter. We shall discuss briefly the possibilities made available by the processing software.

1. Defining the Coordinate Systems

Three coordinate systems are available: a natural centimeter system, a centimeter system, and a user's system.

In the natural centimeter system instructions for moving the plotter are made in centimeters, and the beginning point for the coordinate system is located in the lower left corner of the plotter field. The beginning point for the coordinate system can be shifted to any arbitrary place, bringing about the centimeter coordinate system. In the user's coordinate system, the coordinate axes are laid

out in the units defined by the user, while the beginning point for the coordinate system can be arbitrarily shifted with respect to the centimeter system.

2. Editing Procedures

These procedures make it possible to generate texts (chains) of any arbitrary number of symbols and any arbitrary format, using special symbols (markers) or numbers of the form E, F, I.

3. Procedures for Drawing Curves

These procedures make it possible to draw curves and straight lines of arbitrary thickness, broken or continuous, with or without markers. It is also possible to draw a set of points connected by a broken line, the graph of a function defined by a table, or the graph of a polynomial of any arbitrary degree.

4. Procedures for Drawing Coordinate Systems

These procedures make it possible to draw linear or logarithmic axes for coordinate systems. It is possible to copy these from a text or to lay out original axes. It is also possible to draw either linear or logarithmic grids.

The method of processing these procedures is identical to that in the software supplied by the firm Benson. Thanks to this, the majority of programs using BENSON plotters can be run on the ODRA 1325 computers without any changes, if the computer has the kind of plotter described above. A full description of the processing programs is referred to in work [3].

The system described here constituted by the plotter and the ODRA 1325 computer has been used now for a long time in scientific-technical calculations in the Automations Institute of the Warsaw Polytechnical University.

It has been useful, among other things, in the following areas: automatic design of logic systems, determining pressure distribution and flow in gas pipelines, and in drawing statics characteristic curves for numerical models of industrial entities.

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