NOTE

INTERFACING THE BIOMATION 6500 TRANSIENT DIGITIZER TO AN APPLE II MICROCOMPUTER

S. G. Su (蘇世剛), C. H. Tsai (蔡智宏),
T.-M. Su (蘇志明)* and C. Y. Mou (牟中原)*
Department of Chemistry,
National Taiwan University, Taipei, Taiwan 107, R.O.C.

Key Word Index—Interface; waveform digitizer; microcomputer.

An interface is described which permits high-speed data transfer between the Biomation 6500 waveform digitizer and an Apple II microcomputer system. Through the interface, one can make any number of scans of repetitive data which, having been acquired by the Biomation 6500, may then be averaged, stored and analyzed in a microcomputer environment.

A transient recorder is a very useful tool for processing data from pulse-response experiments over a large range of time scales. Many experimental situations demand that transient signals be digitized, averaged and stored for subsequent analysis.

The Gold Biomation Model 6500 waveform digitizer, a product of Gold Inc., acts as an analog-to-digital converter with a solid-state memory that stores the digital equivalent of an electrical analog signal. This instrument can record at sample rates of up to 2 *ns* per sample, storing 1024 samples and covers an input bandwidth from DC to 100 *MHz*.

The purpose of interfacing the Biomation 6500 digitizer to an Apple II is to utilize the microcomputer to control the 6500 and to pick up transient signals digitized by the 6500. Operations such as signal averaging, data fitting, *etc.*, have been routinely performed on the microcomputer.

Hennau and Ceuterick[1] have described a system for interfacing the Biomation wavefrom digitizer to a PDP-11 computer running under the RSX-11-M operating system and the RS-232 terminal port. We have used Apple II's 6522 interface and assembly language to achieve a simple, inexpensive and fast system.

CIRCUIT DESCRIPTION

The control of the 6500 and data picking is achieved by a few handshakes. The microcomputer controls the following processes: the initialization of the 6500, the receiving of the analog signal; the transfer of digitized data to the microcomputer and the preparation of next routine. These steps can be done by the handshake routine carried out between the 6500 and the Apple II.

The handshake used in this interface is described below:

(a) $\overline{\text{ARM}}$ (Input from Apple II)

If this handshake making a transition from 1 to 0 (binary "1"=HI=3-5 *V*, "0"=LO=0-1 *V*), it indicates that the 6500 is being initialized by the microcomputer, and the 6500 is in a state of preparation and can accept the transient signal.

(b) $\overline{\text{RCD}}$ (Output from 6500)

It indicates that the 6500 is in record mode when it is in a LO state, 0 *V*.

(c) $\overline{\text{OPT}}$ (Input from Apple II)

When hold low, it stops the normal display and indicates the digital output of the data.

(d) **FLG (*Output from* 6500)**

The FLG output indicates that new data is available in the output buffer when it makes a transition from "0" to "1".

(e) **$\overline{\text{WDC}}$ (Input from Apple II)**

This handshake commands the successive digital words during output. If the digital data is accepted by the Apple II then $\overline{\text{WDC}}$=0 is sent from the Apple II to the 6500. The timing diagram of the handshake for the digital interface is shown in Fig. 1.

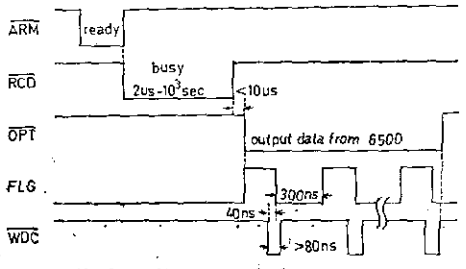

Fig. 1 Timing diagram of the control signal of Biomation 6500 waveform recorder.

The interface between the 6500 and the Apple II is performed by the 6522 interface card which is in the 6500-series logic family. This interface is intended to perform input/output and timing/counting functions in a 6502-based microcomputer system. In principle, there are sixteen flag registers in the 6522 that can be used. The 6502 microprocessor can control these registers directly. For the present application, we use only six registers in the 6522. Table 1 shows the characteristics of the registers that we have used.

Table 1

Symbol	Name
PBD	Input/Output port B
PAD	Input/Output port A
DDRB	Port B data direction register
DDRA	Port A data direction register
PCR	Peripheral control register
IFR	Interrupt flag register

The PAD and PBD are the data input/output port. We utilize pA_0-pA_6 to accept the data from 6500, pA_7 to accept FLG and pB_0-pB_2 to send $\overline{\text{WDC}}$, $\overline{\text{ARM}}$, $\overline{\text{OPT}}$ from the Apple II to the 6500. The function of the operation of PCR and IFR is related so we can use IFR to acquire the information of a change of $\overline{\text{RCD}}$.

The circuit block diagram of the data flow and control of our system is shown in Fig. 2.

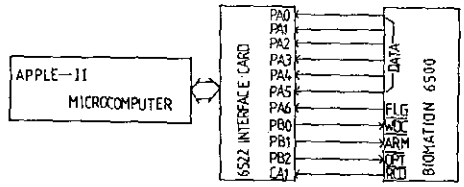

Fig. 2 Circuit block diagram of the interface between Apple II microcomputer and Biomation 6500 waveform recorder.

SOFTWARE

The software contains two parts, the main program written in BASIC language and the control program of 6500 written in 6502 assembly language which can execute the instruction much faster than BASIC. The flow charts are shown in Figs. 3, 4, and 5.

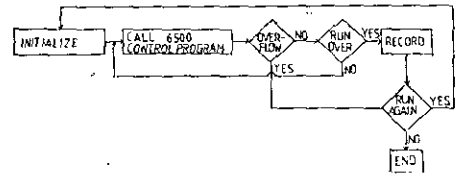

Fig. 3 Flow chart of the main program.

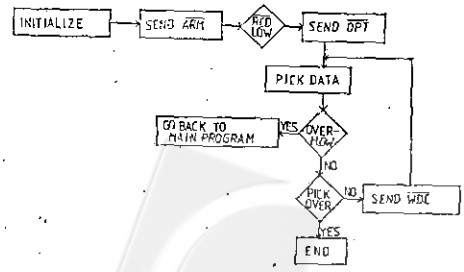

Fig. 4 Flow chart of the data transfer program.

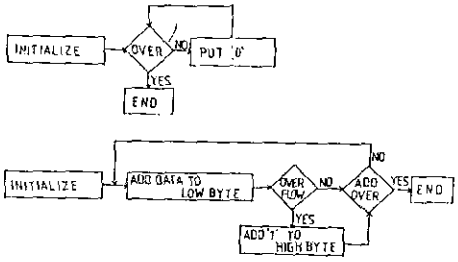

Fig. 5 Flow chart of the memory clearing and data averaging programs.

To execute the data picking and averaging, the main program calls the subroutines putting-zero program, picking-data program, adding-data program and displays the data curve on the monitor screen. The data can then be stored on a disk.

The output data from the 6500 has 1024 words (six bits per word). Putting two zero bits ahead of every word for adding data, we need a $3K$ RAM to manipulate the data. Before the operation we need to clear the $3K$ RAM in Apple II to prepare to store the data. This work is performed by the putting-zero program.

The picking-data program which can send handshake $\overline{\text{ARM}}$, $\overline{\text{OPT}}$, $\overline{\text{WDC}}$ and accept handshake FLG, $\overline{\text{RCD}}$ to or from 6500, can also receive the digitized data from the digitizer and store it in the $1K$ buffer RAM. The overflow of these raw data is checked and if it should occur, the control goes back to the main program. By adjusting the digitizer or experimental conditions, one tries again. Each time, after data-picking is over, the main program calls the adding-data program to add the data in buffer RAM to another $2K$ RAM in which the data sent by 6500 can be accumulated.

After the data is picked and added repetitively in RAM, the main program can divide the accumulated data by the times the data has been added and show the averaged data curve on a monitor screen. The user can decide whether the data is useful and worth storing in disks or just try another run.

The system described can be used in many fields of fast reaction chemical research such as high pressure stopped-flow techniques[2], or p-jump fast kinetics[3]. In our laboratory, it has been used for fluorescence decay measurements[4] and transient photoconductivity experiments[5].

Software packages with detailed operation instructions and assembly language programs are available on request.

REFERENCES

(1) F. Hennau and F. Ceuterick, *Rev. Sci. Instrum*, **52**, 771 (1981).
(2) K. Heremans, J. Snauwaert and J. Rijkenberg, *Rev. Sci. Instrum*, **51**, 806 (1980).
(3) K. Heremans, F. Ceuterick and J. Rijkenberg, *Rev. Sci. Instrum*, **51**, 252 (1980).
(4) J. M. Chen, T. M. Su and C. Y. Mou, "Size of Anionic Micelles in Concentrated Simple Ionic Solution" to be published (1984).
(5) S. G. Su and C. Y. Mou, "Ionic Dissociation Kinetics in Photo-Ionic Dissociation" to be published (1984).

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