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The Development of a Data Processing System with Personal Computer of MSX® Standard System for Flow Injection Analysis

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Abstract

Since one of the merits of flow injection analysis (FIA) is rapid measurement, the time taken for data processing reduces the usefulness of the method. In this study, a personal computer of MSX® standard system, which has a Z80A-type chip as CPU and more than 8 Kbyte of RAM, with a data acquisition system of our own making, was introduced to facilitate data processing for FIA; a program written in MSX-BASIC was also developed. This system was applied to determination of glucose in control sera, and the results were compared with those of an analog recorded system. It was found that our 8 bit system had enough resolution for the FIA data processing.

Since one of the merits of flow injection analysis (FIA) is rapid measurement, the time taken for data processing reduces the usefulness of the method. As the data in FIA may have many peaks, it becomes hard to measure the peak heights manually. A data processing system for FIA makes the processing time shorter, and removes many measurement troubles.

Many data processing systems have been developed by researchers who took account of these points. However, these systems are almost all for high performance liquid chromatography. We use just a few parts of their multiple functions for FIA data processing in measuring only the peak heights. Their systems are also very expensive. In the previous paper[1], we have developed a data processing system that has a simple configuration and enough resolution for FIA data processing, and we wish to report details of this work.

The configuration of our data processing system is shown in Fig. 1. The signals from the detector are converted by an A/D converter to digital signals which can be processed by a micro computer, and the data are typed by a printer. The personal computer for data processing is MSX® standard system (abbreviated as MSX). MSX has a Z80A-type chip as CPU and more than 8 Kbyte of RAM. Some merits of MSX are as follows: 1) the configuration of hardware is simple, 2) the specifications are opened to the public, 3) its hardware and software are widely compatible, 4) they are low in price, 5) in Japan alone, more than ten companies deal in them, 6) it is easy to develop programs on an assembler. Recently MSX has been used in various fields and has become an important part of our life.[2,3] When MSX was improved in 1986 to MSX-2, the ability of functions became wider; thus more applications of MSX are expected soon.

Experimental

A data acquisition system (abbreviated as DAS) that can convert the voltage from the detector to digital signals which can be accepted by MSX was developed. The DAS consists of an interface circuit, an A/D converter LSI, and an amplification circuit. The A/D converter LSI is ADC0809 type. This is a successive approximation type LSI which has a resolution of 8 bits. Because the LSI functions at +5 V single power source,

the connection to Z80 type microprocesser of CPU through the Input Output (abbreviated as I/O) port of MSX, is easy. The conversion of the LSI is relatively high speed (time ca. 100 μs) in spite of its reasonable price and so the sampling interval can be selected from over a wide range. The way of interface to Z80A type CPU is based on the so-called accumulator I/O (I/O mapped I/O) which runs A/D converter LSI by I/O access command operated by BASIC, IN and OUT, or which inputs converted data.

Some programs for FIA data processing were developed. They were all written in MSX-BASIC. The apparatus used were a personal computer (Hitachi, MB-H25, RAM: 32 Kbite), a printer (Brother, M 1009X), and a data recorder [NEC PC-6082 (DR-320)].

The reproducibility of the peak heights obtained using an A/D converter depends greatly on the intervals at which data are taken in. In this work, the influence of this interval on the scatters of peak heights was examined using a basic FIA system.[4] When the intervals at which data were taken in were 50 and 100 ms (sampling rate: 20 and 10 /s), relative standard deviations were calculated. The intervals were controlled by the repeat number in the For-Next command loop. The apparatus and reagents used were similar to those described in the previous report[4] except for the spectrophotometer (Kyowaseimitsu, KLC-800).

This system was applied to determination of glucose in control sera, and the results were compared with those from an analog recorded system. The FIA system used in this work was similar to the system previously described.[5]

Results and discussion

The circuit[6,7] and the parts for DAS of our own making is shown in Fig. 2 and Table 1. The operation signals provided to LSI for A/D conversion are "START" and "ALE". "ALE" is the signal in order to select the channel of the analog multiplexer

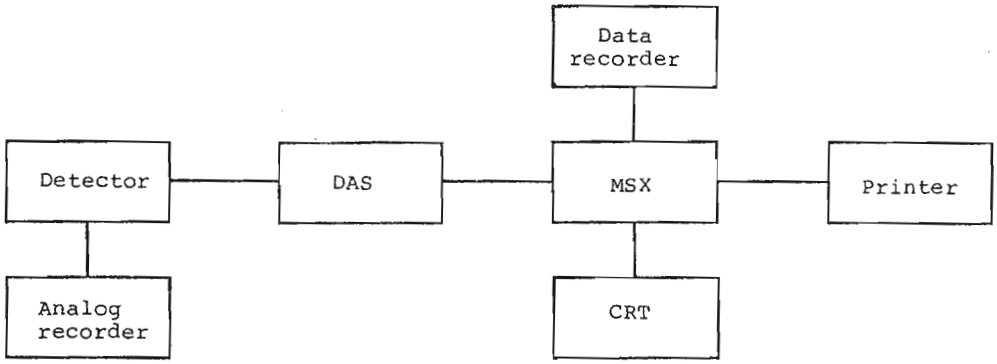

Fig. 1 Configuration of the data processing for FIA

Table 1 The parts of our own making DAS

Parts	Standard	Number
TTL IC[a]	74LS10	1
	74LS27	1
	74LS93	1
LSI[b]	ADC0809CCN (8 bit A/D converter)	1
Resister	1 KΩ (variable)	1
	4.7 KΩ	1
	20 KΩ	1
	220 KΩ	1
Capacitor	0.01 μF, 16 V (ceramics)	1
	0.1 μF, 25 V (ceramics)	4
	10 μF, 16 V (tantalum)	3
Writing board	Sunhayato MCC-152	1
OP AMP[c]	LM308 N	1

[a] "The TTL IC manual", ed. Kunio Inokai, CQ Shuppan, Tokyo (1986).
[b] "The A-D/D-A converter IC manual", ed. Yoshiyuki Nagahashi, CQ Shuppan, Tokyo(1986).
[c] "The monolithic OP AMP manual", ed. Shigehiro Yamada, CQ Shuppan, Tokyo(1986).

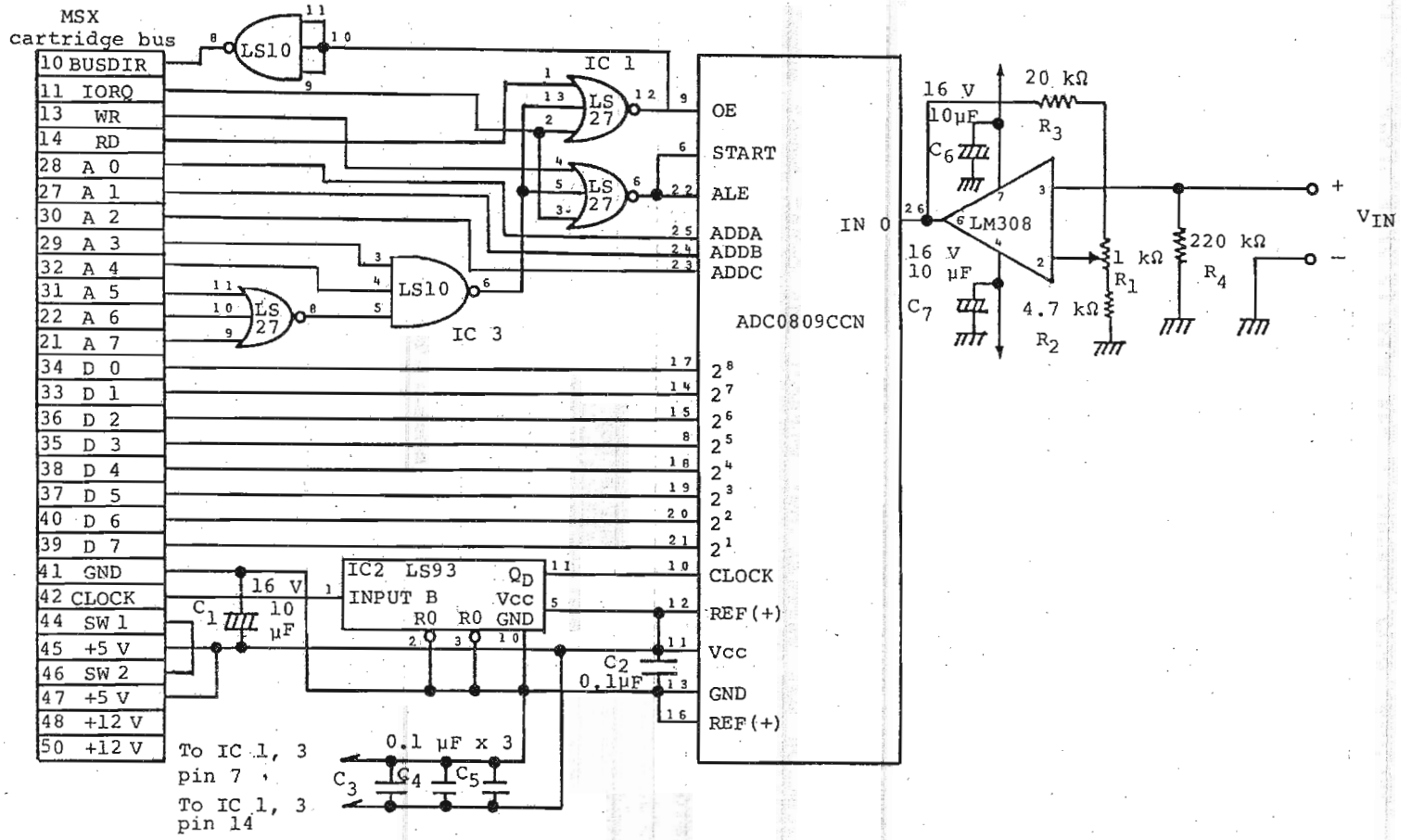

Fig. 2 The circuit for DAS of our own making

(and channel addresses are input to three pins between ADDA - ADDC). Although only channel 0 was used in this study, it is possible that some detectors can be connected to MSX without mechanical operation if only some suitable terminals are prepared. "START" is the signal in order to start A/D conversion. The process to select the channel of the analog multiplexer and the process to start A/D conversion are both carried out at the same time, because of a short circuit between ALE signal line and START signal one. Since the voltage range of output from the detector is 0 to 1 V (correspondence to 0 - 1.000 Abs) and that of input for A/D converter LSI is 0 - 5 V, the voltage from the detector was input to A/D converter LSI after the amplification by an operational amplifier.[8] However, the change of the rate of amplification was made to enable adaptation to various experiments. As the power source for amplification was supplied from I/O port terminals of MSX (±12 V), the amplification was carried out without any other power supply device. For the purpose of prevention of noise[7,9], the part of analog circuit (Amplification) and that of digital circuit (A/D conversion and interface) were kept separated by a distance of 25 cm.

Flowcharts of the program for data processing to FIA are shown in Fig. 3. The program comprises the main program for processing data, and the subroutine program for measuring peak heights. In the main program, the initial conditions (including date, the concentration and number of standard samples for calibration) are input. The calibration curve is calculated with peak heights for each concentration standard sample by the least square method. Then the peak heights of the unknown sample are measured, and the concentrations are calculated from peak heights using a calibration curve. This program was modified to deal with various measurement situations, including the trouble of air in the tube, electrical noise, and artifical mistakes. Accordingly the

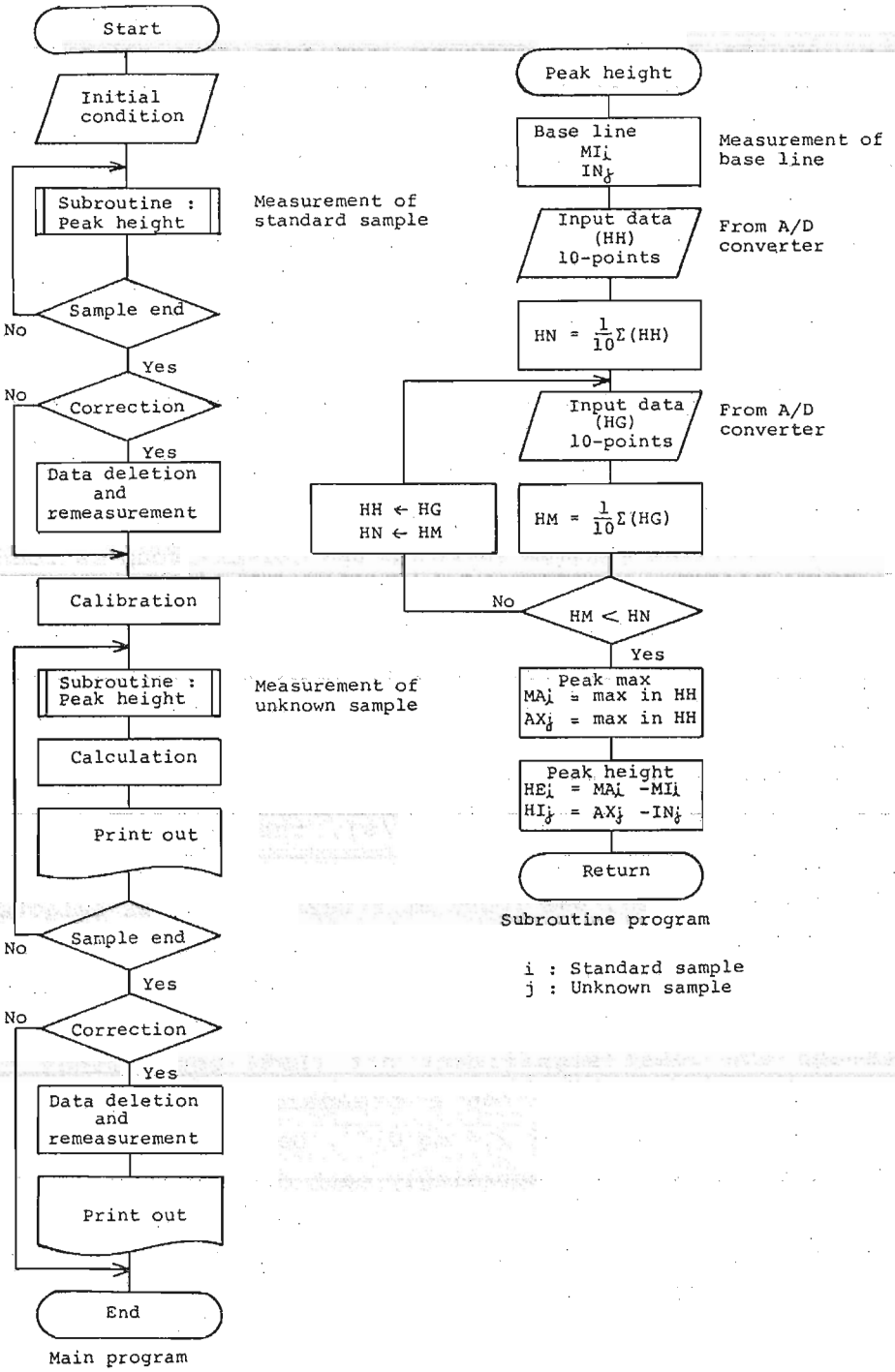

Fig. 3 Flowcharts of the programs for the data processing and the peak heights measurement with FIA

removal of mistaken data and the remeasurement can be carried out. In the subroutine program, two data sets (30-points in one group) are taken in and the rise of the peak is discriminated according the value (threshold) obtained by subtracting the mean of second group from the mean of first group. When the threshold is more than 0.8, the mean of the former is rounded off to a natural number and this number is taken as the value of the base line. When the threshold is less than 0.8, the former group mean is canceled and the value of the latter is put in to replace the former. Then the new data set of 30-points is taken in as the latter set. These are countermeasures against the drift of base line. In order to measure the value of the peak top, a similar method was developed. When the mean of the latter group is less than that of the former, the maximum value in the former group is rounded off to a natural number as the value of peak top. The value obtained by subtracting the value of base line from the value of peak top is a function of peak height. When the above process is completed, the command of returning to the main program is carried out.

When the intervals between data points were 50 and 100 ms (sampling rate 20 and 10 points/s), the relative standard deviations were 0.84 and 1.16 % (n = 10). As the significant difference ($p < 0.01$) was found at F-test, 50 ms was selected.

The concentrations of glucose which were measured and calculated from the chart of the analog recorder, and a part of the data printed out for this system, are shown in table 2. Although the least significant bit (LSB) corresponds to a change of 0.077 mg dl^{-1} on a standard sample, it really corresponds to a change of 2.4 mg dl^{-1}, because unknown samples were diluted 31 times. Accordingly each difference of 1 mg dl^{-1} between analog and digital data in Table 2 did not amount to one LSB for 8-bit resolution. This suggests that the data processing in the system is perfect.

Table 2 The measurement of glucose in control sera by MSX and analog recorder

Sample	MSX/ mg dl^{-1}	Analog recorder/ mg dl^{-1}
Fisher Scientific		
Sera Chem level 1	78	77
Sera Chem level 2	246	245
Cooper Biomedical		
Hyland Diagnostics I	84	84
Hyland Diagnostics II	245	245
Sanko Junyaku		
EXA normal	90	90
EXA abnormal	319	318
Wako Pure Chemical Industries		
Control Seram I Wako	72	71
Control Seram II Wako	250	249

Conclusion

The authors have been using vernier calipers with digital indication (Mitutoyo CD-20S) to measure peak height. As the prices of MSX and the calipers are equal, MSX is an exceedingly economical instrument. The A/D converter board in this work has only a few parts and is easy to make. Although the system has diverse applicability to various needs, its operation is very easy for the interactive mode. Moreover, the time for data processing has been shortened to less than one second by introduction of the system. The more data, the shorter the processing times of the total system become. We are certain that the system will facilitate routine work on FIA.

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