A portable low-cost microcomputer system for glasshouse climate control.

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For research in glasshouse climate control a low-cost portable microcomputer system is described. The system is based on the Siemens SMP-80 modular microprocessor bus. Instead of the original microprocessor card the Apple II personal computer is used. The system can easily be operated and features grafics on a TV monitor.

1. Introduction

The introduction of the (micro)computer in glasshouse climate control facilitates the application of more sophisticated control algorithms. (Udink ten Cate et al., 1977, 1979; Hashimoto, 1980). An accurate control may lead to better energy efficiency (Challa et al., 1980; Seginer, 1980).
In the Netherlands research in glasshouse climate control has been carried out with large computer systems at various Institutes and Experiment Stations. Lack of knowledge of the operating system, the program language (mostly assembler or process Fortran), the structure of the program, as well as the dependence on a system operator/programmer makes the majority of the systems not readily accessible to a research-worker.
Furthermore a research project generally has its specific requirements with respect to computer programs, the number of sensors, the sample-time, the methods of data analysis and so on.
In research in glasshouse climate control usually one certain aspect is examined. It would be better when the research-worker has a small system of his own which is easy to operate and can quickly be adapted to his requirements. At a working-party in Wageningen last year several computer systems were presented, among others a microcomputer system based on a KIM computer (Killeen et al., 1980).
The wide-spread acceptance of the personal computer and also the decrease of cost for modular electronic units makes it possible to present a more sophisticated system with relatively little extra expenditure.

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2. The microcomputer system

The microcomputer system consists of an Apple II personal computer linked with the modular Siemens SMP-80 microcomputer system. The Apple II is easy to operate (operating system is stand-alone BASIC). The interface cards for analog signals which can be delivered for the Apple II system are not suitable for a more professional design (only 7 slots available). An industrial system is for example the SMP-80 system. This "EUROCARD" system has more interface space and analog and digital I/O is "off the shelf" available. Also there is the facility to add-on interface cards of own design, which makes the system adaptable to the specific requirements of the research-worker. Instead of the original (8080 or 8085) microprocessor card the Apple II personal computer is used. A specially designed interface links the Apple II (6502 micro) with the SMP-80 bus. The advantages of a professional modular system combined with a personal computer are:

1. low-cost terminal (Apple II)
2. extended BASIC
3. add-on RAM memory (32 K in Apple II)
4. reasonable grafics (192 x 280)
5. cassette recorder interface.

The net-effect is a system characterized by an attractive price/performance ratio.

3. Lay-out of the system

In order to test new algorithms for temperature- and ventilation control the system should measure 3 temperatures (wet, dry bulb and pipe temperature) with PT-100 transducers, 2 window apertures (pot. meters) and control the motors of the valve from the heating system and the windows (weather-side and lee-side). These requirements resulted in the selection of the following SMP-80 modules:

a. ADC card, 8 channels differential in
b. relay card, 16 contacts
c. current source, 8 channels (own design)
d. watch dog timer, alarm (own design)
e. power supply.

Figure 1 shows the system set-up.

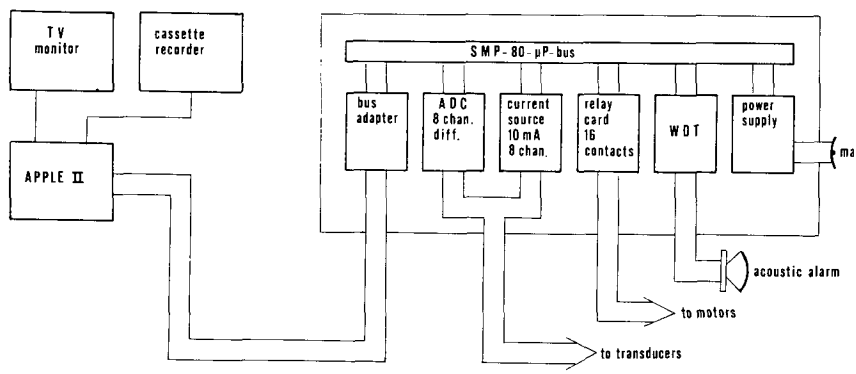

Figure 1.

4. Software features

In the standard BASIC of the Apple II, I/O commands are possible by the "PEEK and POKE" BASIC statements. An interface program written in machine-code (transparent for the BASIC user) enables the user to do I/O calls in order to transfer the parameters as BASIC variables. Distinction between a BASIC and an I/O print statement is made by preceding a "CTRL-S". A sample program to measure a temperature with a PT-100 transducer at channel 1 is given below:

```
10 S$ = CHR $ (147)                    : REM CTRL-S
20 CALL 24576                          : REM initializes interface
30 PRINT S $ "CUR (1)"                 : REM current 1 on
40 PRINT S $ "ADC (1/T)"               : REM convert channel 1
50 PRINT S $ "CUR (8)"                 : REM current off
60 PRINT "TEMPERATURE ="; INT (((T/4095) x 5000)-1000)x.25);"C"
70 PRINT S $ "WDT"                     : REM watch dog timer
80 GOTO 30
90 END
```

For the ADC conversion two arguments must be specified, the first one is the variable containing the number of the channel (0 to 7), and the second one must be the BASIC variable to which the result of the conversion is returned. For the current source there is one argument, specifying the channel number (0 to 7), number 8 causes switching off all currents.
For the relays there are two arguments, the first one specifying the relay number, the other one must be 0 or 1 (off or on).
147 is the decimal value of the ASCII-code for CTRL-S.

5. Experience with the system

The described system is operational about half a year.
First it was tested on a model-glasshouse, then field trials were done to test new algorithms for ventilation control (Boswinkel, 1980) and in the future temperature control will be carried out (Udink ten Cate et al., 1980).

6. Conclusions

A low-cost easy to operate system was presented. The costs of this system will not exceed 9000 guilders. Because of this it can be placed at the disposal of research and education.
The system is easy to extend, for example a Floppy-disk, TTY modem plus telephone is easily added by using the Apple II interface slots. Also there is the possibility to simulate with a simple simulation language based on BASIC, namely BDARE (Korn, 1979).

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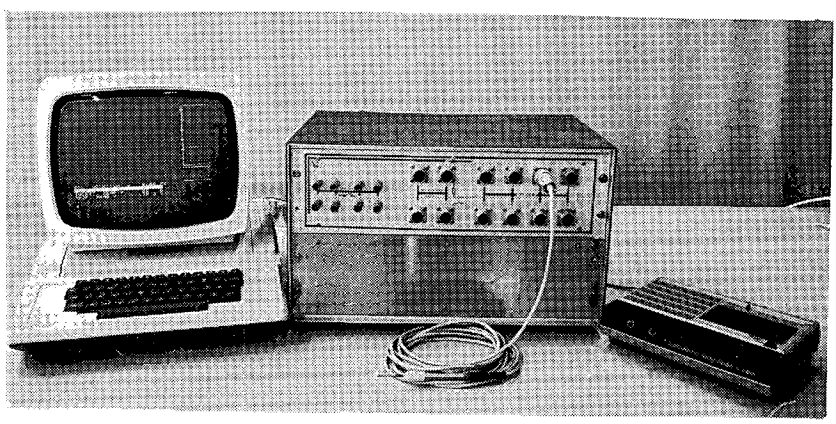

Fig. 2 The microcomputer system.