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Impact of Microcomputers on Education
— Issues and Techniques

MATHEMATICS AND SCIENCE CENTRE
NGEE ANN POLYTECHNIC
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Microcomputer Applications Laboratory

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Abstract

The design flexibilities and capabilities of the microchip has proliferated its use in automation and controls. Keeping this in view a general purpose microprocessor training course covering lectures supported by practical laboratory classes, is proposed for pre-final and final year Electronics Engineering under-graduate students to familiarise them with the applications of microcomputers in process-control, data acquisition and Robotics.

A single-board computer, based on INTEL 8086 microprocessor is proposed to be used for demonstration of these applications. Various ADCs, DACs and logic drivers with opto-couplings will be used to provide system interface with the real world for applications of process-control and data-acquisition whereas different drivers nd actuators shall be made use of for Robotics. Various process phenomena are simulated on the computer inputs by switches, push buttons and potentiometers, the control response are studied on recorders and displays.

Software packages for these three applications are to be kept on a floopy system. For demonstration, individual software package can be loaded into memory and then executed in single-step command or by direct run for analysing the results.

Introduction

Due to the ever increasing performance on the one hand and reduction in the cost of hardware and software on the other, computers and particularly the micros, are finding extensive use in industrial applications. Correspondingly, therefore, it has become imperative to transfer the knowledge of theory and practice of micro-computers and their applications to the University sophomores at the under-graduate, graduate level and to in-service engineers in the field.

With a view to introduce microcomputers at the under-graduate level, a lecture course followed by microprocessor practice sessions was introduced. A microprocessor Laboratory in this Department was set-up about three years back. These are based on Intel 8085. The Microprocessor kits were used by the final year Engineering students in the Microprocessor laboratory for hands-on experience and for working on microprocessor based projects. It was observed that as far as the learning/teaching of micro-processor architecture and assembly language is concerned these kits were helpful but were found to be lacking in developing appreciation for applications. This resulted in loss of enthusiasm as it did not enable them to implement working models.

Keeping the above limitation in view, it is now propsed to set up microcomputer applications laboratory with the following objectives:

1. To develop and provide ready-made interface modules so that students are able to learn to use a single board computer and hook up a working model to demonstrate the following applications:

   i) Data Acquisition,
   ii) Process Control, and
   iii) Robotics.

2. These working models should be simple enough so that by keying in small assembly language programs (which they may have learnt in the introductory course) the students can study and analyse the applications as proposed above.

3. The system should be interactive and the learner should be able to work with high level commands of the operating system. The operating system for this reason should be real-time.

4. The entire courseware has to be made broad enough to cover the learning needs of the under-graduate, the graduates and the in-service engineers and technicians.

System Hardware

To meet the above objectives it is proposed to use an iSBC 86/05 single board computer available from Intel. This computer board consists of 8086 16 bit CPU, 16K bytes of RAM, 16K bytes ROM, 24 rpogrammable I/O lines, one RS 232C interface, two 16 bit timers, and nine levels of priority interrupts. The ROM is expandable to a total of 64K bytes on board. Following features influenced the selection of hte iSBC 86/05:

1. It is a single board Multibus System with the provision to mount two small extension boards for parallel I/O and floppy disk controller. The multibus is ideally suited for 'control' applications.

2. The support software including the real-time operating system (iRMX 86) for this hardware is readily available from Intel.

3. The availability of an Intel MDS Series-IV system is helpful in testing the developed software.

The other hardware includes:

1. a CRT terminal which communicates with the processor board through RS 232C serial interface,

2. a 51/4 inch floppy disk drive which is controlled by an extension control board, and

3. 24 additional programmable parallel I/O lines are provided by connecting an expansion board to the main computer board. This makes the total I/O lines to 48.

System Software

The system software is directly available from Intel. The application software which would be developed for individual application is built around Intel 6.6K bytes iRMX 86 (Figure 1) real-time operating system which runs on iSBC 86/05. The operating system provides services of interrupt management, standard driver routines for controllers, and data file maintenance commands. The nucleus layer provides facilities to manage various processes and to communicate between them. The Basic I/O system enables communication with peripheral devices through devices drivers. These device drivers provide the system with four basic functions needed to control and communicate with devices viz., to initialise, to finish, to queue and to cancel I/O. The standard devices for are CRT, Keyboard, printer, etc., and they communicate serially through USART while the non-standard I/O devices like ADC, DAV, LEDs and switches communicate via parallel I/O ports. A device driver is separately written for the latter and is included as part of the system.

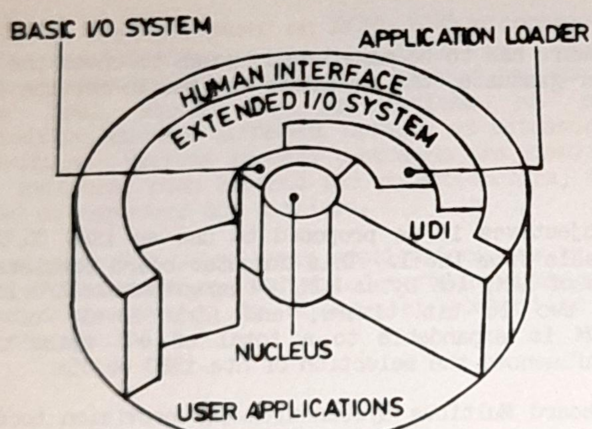

Fig. 1 iRMX 86 OPERATING SYSTEM

The iRMX 86 bootstrap loader which occupies less than 600 bytes of PROM is used for loading the initial system from floppy disk into memory and begin its execution. In addition an application loader is provided for loading application programmes, human interface commands and data from the floppy.

Courseware

1. Recapitulation: A few lectures are needed to familiarise and recapitulate the underlying theory and principles of microprocessor and covers the following major topics:

   i) Fundamental of Microcomputers 5 hrs

   ii) Various Microcomputer configurational and applications 5 hrs

   iii) Assembly language for 8086 5 hrs

2. Lectures: With the above background, lectures on application aspects covering the following topics are required to be delivered:

i)	Analog-to-digital conversion, digital to analog conversion and concepts of application hardwares and its interfacing to microcomputer	10 hrs
ii)	Over view of data-acquisition, process control and robotics	10 hrs
iii)	Familiarization with iRMX 86 and its commands	10 hrs

3. Applications:

A) Preliminary Applications - Some laboratory exercises are carried out and demonstrated to the students to familiarise them with the microcomputer, its operating system and the Basic language input/output operations. Following familiarizations experiments on data-acquisition are then expected to be performed:

i) The first experiment incorporates I/O operations like -

- inout the A/D convertor data
- depending on the level of the input signal and set-point, the corresponding LEDs at the output port lights
- putting on an electric heater through output port relay driver circuit for 10 seconds and then putting it off.

ii) In the second exercise sine, square and triangular waveform inputs from signal generator are connected to A/D convertor channels. Using a micro the sampled and converted signals are stored in continuous memory locations. The following are then carried out on the stored samples:

- the signals can be reconstructed through A/D convertors and displayed on CRO
- any waveform which is a function of these three waveforms can be obtained by processing the stored digital values in the computer and then outputting them through A/D convertors
- the samples can be delivered at a slow rate to A/D and recorded on a chart

After completing these exercises, the learners are expected to carry out more involved experiments in Robotics and process control.

B) Advanced Applications:

a) Robotics: A three joint robot is proposed to be used for this purpose as per the schematics indicated in the Fig. 2 (Ref. 6). Each of the three joints are independently controlled and positioned by three stepper motors. One eight bit port of the computer is used to send pulses to all the stepper motors, out of which 4 bits are reuired for delivering pulses to the individual motor buffers and the remaining four bitsare decoded to select the individual buffer. A stepper motor controls the angles of each robot joint. Thus transformations are needed to convert cartesian co-ordinates into angles of each joint, and then into required number of motor steps.

The position monitoring is achieved by the potentiometers mounted on each joint and potentiometer signals are fed to the microcomputer after having conversion into digital (Fig. 3). The microprocessor constantly compares the present position with the desired position. When the desired position is attained, the microprocessor stops sending pulses to the motor. The gripper is actuated with the help of a solenoid which move the two robot fingers with the help of a plunge when the latter is pulled by the solenoid against the spring force or when it is released.

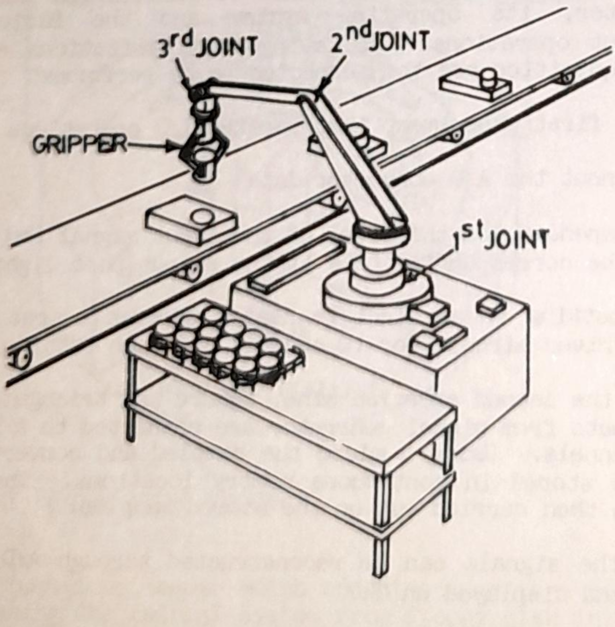

Fig. 2 Mechanical Details of Robot

The robot shall be designed to be operated in the following two modes:

1) In the manual mode a small hand-held keyboard controller is used to teach the students to run small manipulation programs. This keyboard is made to communicate to the computer through I/O ports. Every key on this controller has got a corresponding command routine which is executed when the latter is depressed.

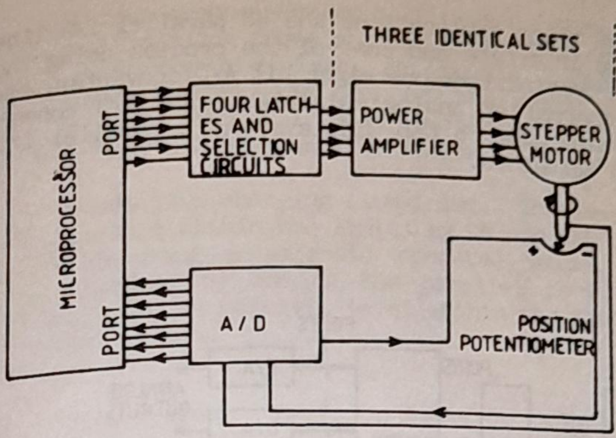

Fig. 3 Hardware Layout for Robot

The students do not need to operate system commands in manual mode. Small routines can be written by students in 8086 assembly language or in any higher level language preferably Basic and compiled to obtain machine code using MDS Series-IV. These small programs are then loaded into the single board computer RAM and executed giving commands from the controller board.

ii) The advanced control mode uses iRMX operating system commands to replace the commands used in its manual mode. In both modes students will conduct experiments for coordinate transformation. They feed the various angles through the CRT key board or controller board and position the robot joints to the corresponding cartesian coordinates. In another case the students key-in the coordinates and position the robot arm(s) at proper angles. The coordinates and corresponding angles are also displayed on the CRT screen.

In another set of experiments, a pair strain gauge is attached to the gripper arm for weighing and sorting the objects according to their weight (as shown in the schematic of Fig. 2). The strain gauge output is fed to an A/D convertor through a bridge unbalance. Using the various software routines the objects falling within certain limits of weight can be sorted and weighed. The magnitude of the weight is also displayed on CRT.

b) Process Control: Three different process control applications have been selected to be implemented using the microcomputer:

i) Level Control,
ii) Flow Control, and
iii) Temperature Control

For each of these applications the 48 parallel I/O lines are used (Fig. 4) to interface and control the process using the following I/O device combinations-one eight bit A/D convertor, one eight bit port for control of analog multiplexer and A/D convertor, two 8 bit D/A convertors, 8 LED displays and 8 parallel I/O lines for alarms and actuators.

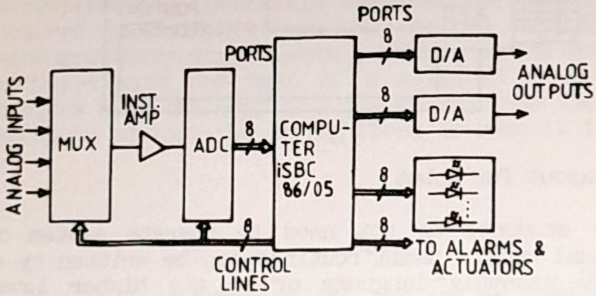

Fig. 4 Interface setup for Process Control

1) Level Control: In this application a small cylinderical container is proposed to be used with inlet tap mounted at the top and outlet tap at the bottom for draining. The levels in the container is sensed using an ultrasonic detector mounted at the top which gives an analog signal proportional to the level in the container.

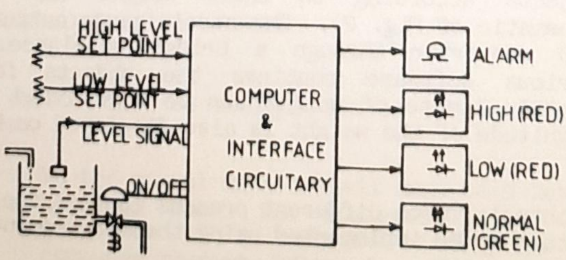

Fig. 5 Level Control

A four channel analog multiplexer is used for time division multiplexing three signals from level sensor, low level set point and high level set points. Each one is converted into digital and fed to the computer. The reference signals from the potentiometer set points are required to adjust the high and low limits of levels in the tank.

There is a changing flow inlet. The level in the container is kept within the limits by ON and OFF operation of outlet tap using a solenoid operated value. The solenoid is operated by one of the parallel port I/O lines and the driver, to maintain level within the limits of high and low set points.

ii) Flow Control: Here, a Rosemount Electronics differential pressure cell is used to sense the pressure drop across the orifice in a two inch diameter pipe-line (Fig. 6). The DP cell delivers a 4-20 mA current signal proportional to the water flow in the pipe. The span and zero adjustments are available on the DP cell for range spread and contraction. 4 mA output signal represents zero flow and the 20 mA full flow for the adjsuted range. A 250 ohm resistance converts the current signal to 1-5 volts at the input of analog multiplexer, which is later converted into digital and fed to the computer. Another input to the multiplexer is from the set point potentiometer as per the flow set point adjusted in litres/minute.

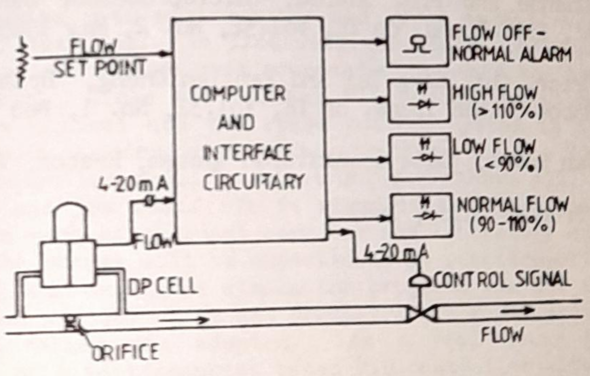

Fig. 6 Flow Control

After processing the two inputs, the computer delivers the PID control signal to D/A convertors which is subsequently converted into current signal and delivered to control value which in turn will adjust the flow at the given set point. The implementation of PID control algorithm is discussed in detail in Ref(3).

iii) Temperature control: The temperature control techniques and analysis of the data has been discussed in detail in Ref(2). This is not repeated here as the same can be implemented with some modifications.

To achieve advanced and better control in all the process control experiments, students can try to implement higher level controls of PID, feed forward and cascade controls.

Conclusion

A typical microcomputer applications laboratory set up is proposed in this paper covering the three most potential industrial uses of the microprocessor. An appropriate scheme of lectures followed by relevant experiments has also been proposed accordingly. The scheme together with the application laboratory is planned to be started in this department. It is believed that the proposed microapplications laboratory will go a long way to help not only in the formal degree level courses but also for the non-formal education of engineers in industry.

It is understood that this type of training in advancing microprocessor applications is going to be of immense use to industry as well as to the Institution.

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