MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent unit of MAHE, Manipal)

Industrial Automation (ICE 3252)

Computers in Process Control

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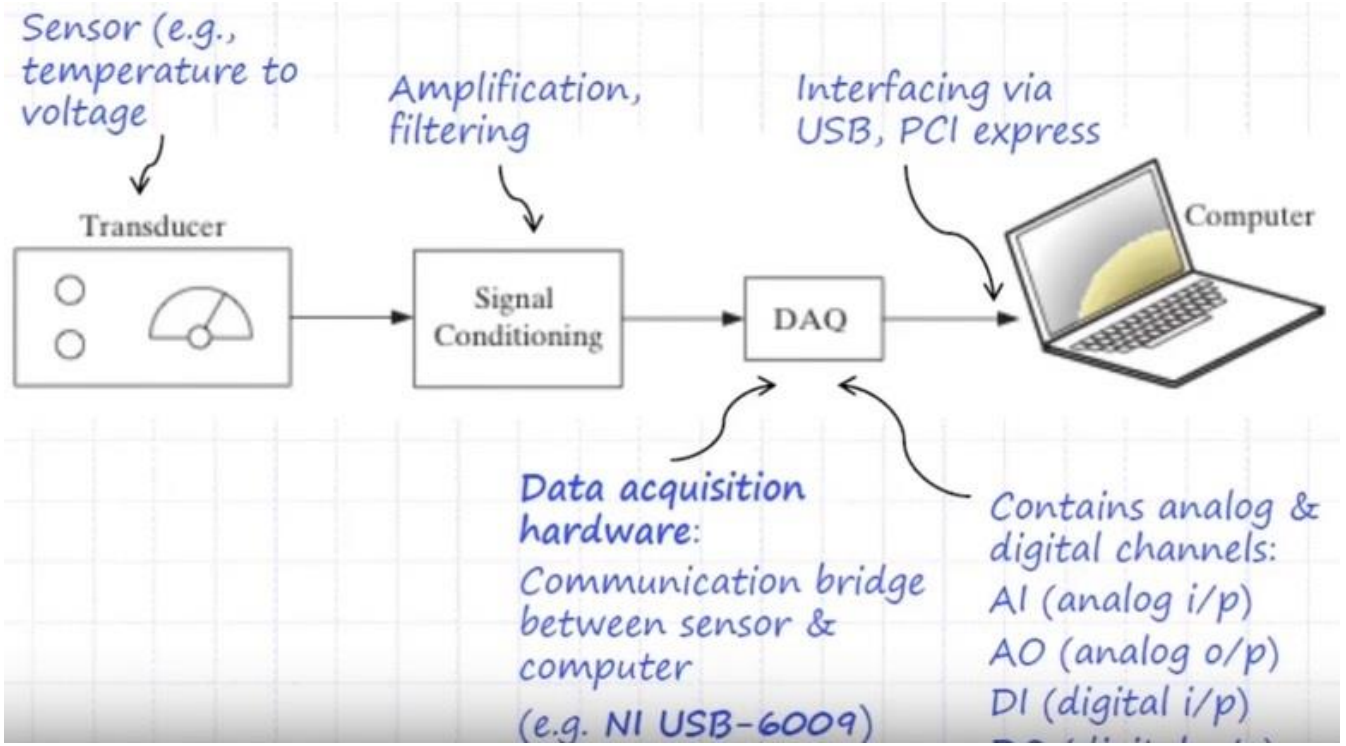
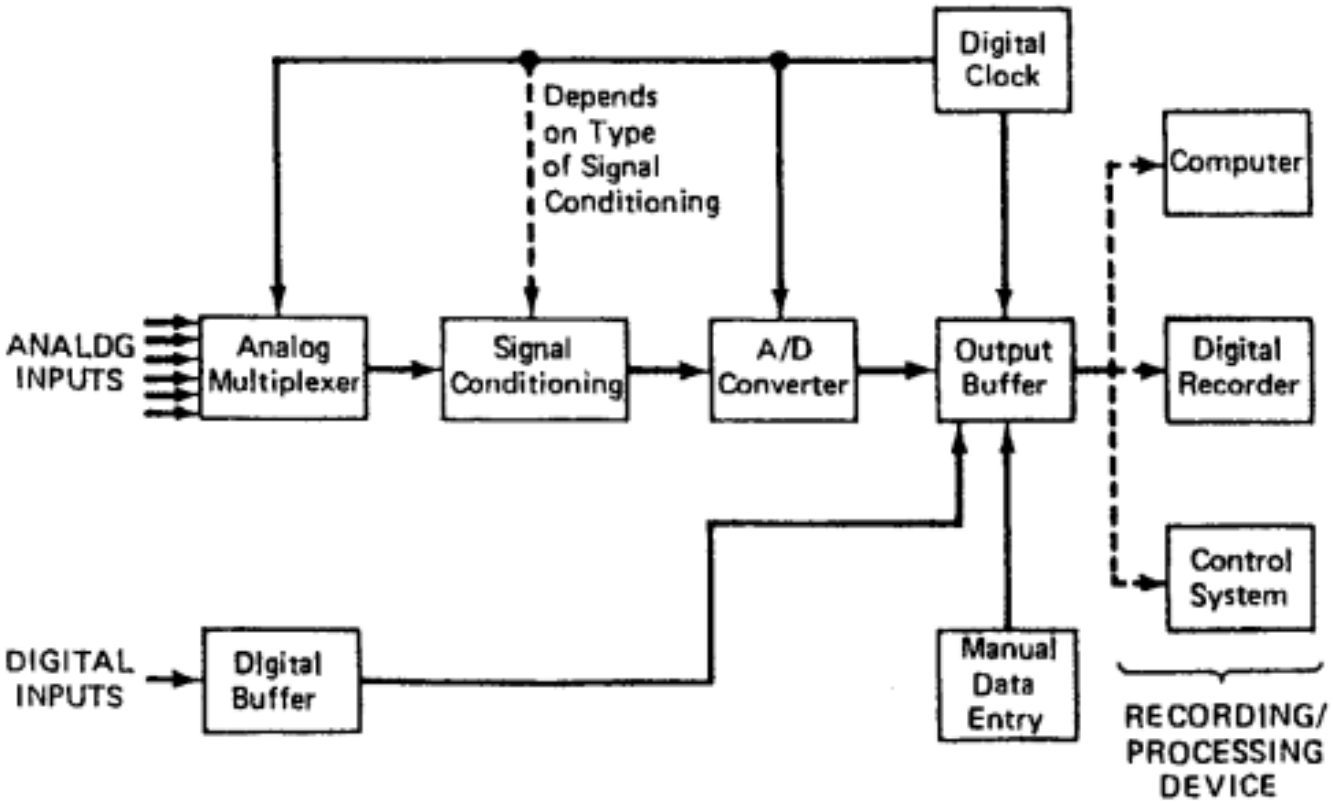
Data-Acquisition System

The collection of hardware and software components that enable a computer to receive physical signal.

an electronic instrument, or group of interconnected electronic hardware items, dedicated to the measurement and quantization of analog signals for digital analysis or processing.

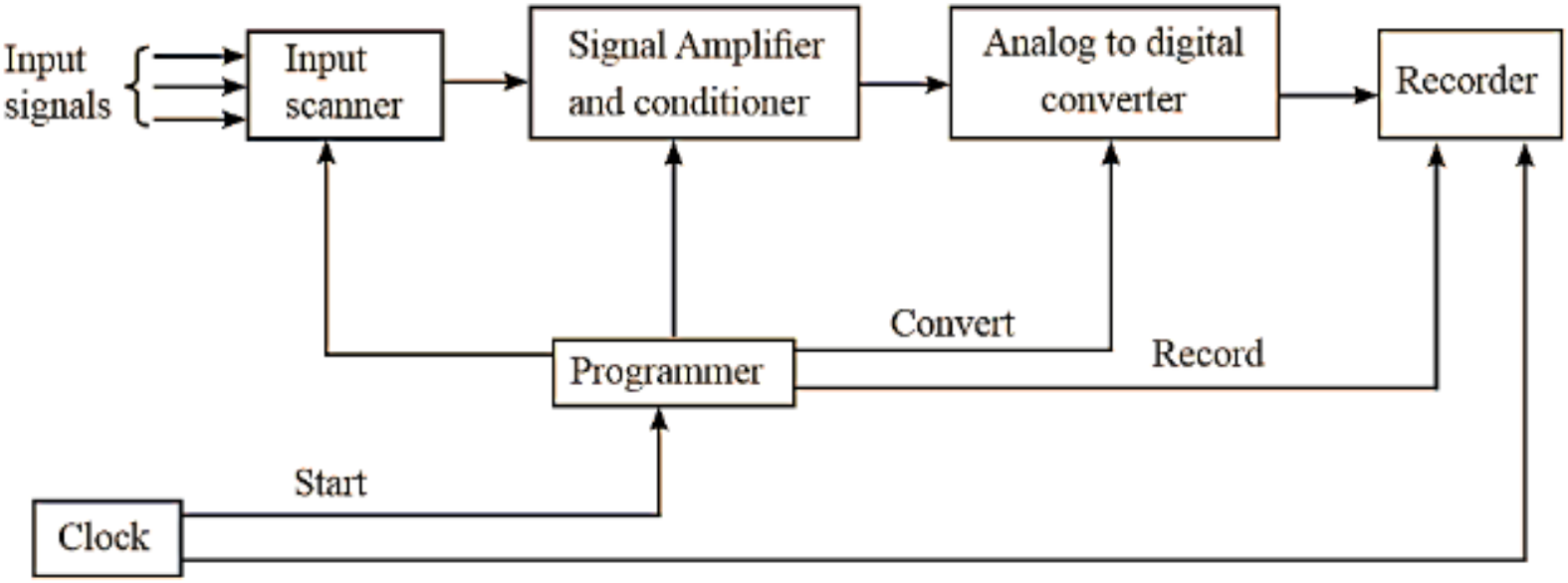



Digital Clock
Depends on Type of Signal Conditioning
Computer
ANALDG INPUTS
Analog Multiplexer
Signal Conditioning
A/D Converter
Output Buffer
Digital Recorder
Control System
DIGITAL INPUTS
Digital Buffer
Manual Data Entry
RECORDING/ PROCESSING DEVICE

Data logging or data recorder

- The term ‘Data Logging' refers to collecting or gathering data over a period of time.
- A data logger is a device that can be used to store and retrieve the data.
- Data loggers capture, measure, and analyze physical phenomena from the real world.
- Light, temperature and pressure are examples of the different types of signals that a Data logger can measure.
- A data logger is often a hand- held battery operated device which has a large amount of memory.

Basic data logger



Basic parts of a Data Logger Operation

1. Input scanner
2. Signal conditioner
3. A/D converter
4. Recording equipment
5. Programmer

Data logger

1. Input Scanner

The various input signals fed to the input scanner are temperature, pressure, vibrations, ON/OFF signals etc. The input scanner is an automatic switch that can select only one input signal at a time. In modem scanners the rate of scanning is upto 150 inputs.

Data logger

2. Signal Amplifier and Conditioner

The input signal selected by scanner is a low level signal. Hence a signal amplifier is used to amplify the low level signal so that the input signal is maintained at 5 V level. The signal amplifier should possess certain characteristics like precise and stable D.C gain, high signal to noise ratio, good linearity, high impedance etc.

The signal conditioner is placed between scanner and analog to digital converter. It is a linearising circuit i.e., if a signal varies non linearly with respect to the measured parameter then linearization of signal is done by the signal conditioner.

Data logger

3. Analog to Digital Converter

The data loggers handle the data only in digital form and hence the analog signal, if any, have to be converted into digital form by employing analog to digital converter. The digital technique is used because it measures very small signals without loss of accuracy. The analog signals that are converted to digital form are suitable to drive the digital recorders.

4. Recorder

The data logger drives the output recorder which prints the signals obtained from the analog to digital converters. The recorder may consist of either typewriter or a punched tape. The typewriter provides a conventional log sheet with results in tabular form. Punched paper tape is used when the recorded data has to be analysed further in a digital computer.

Data logger

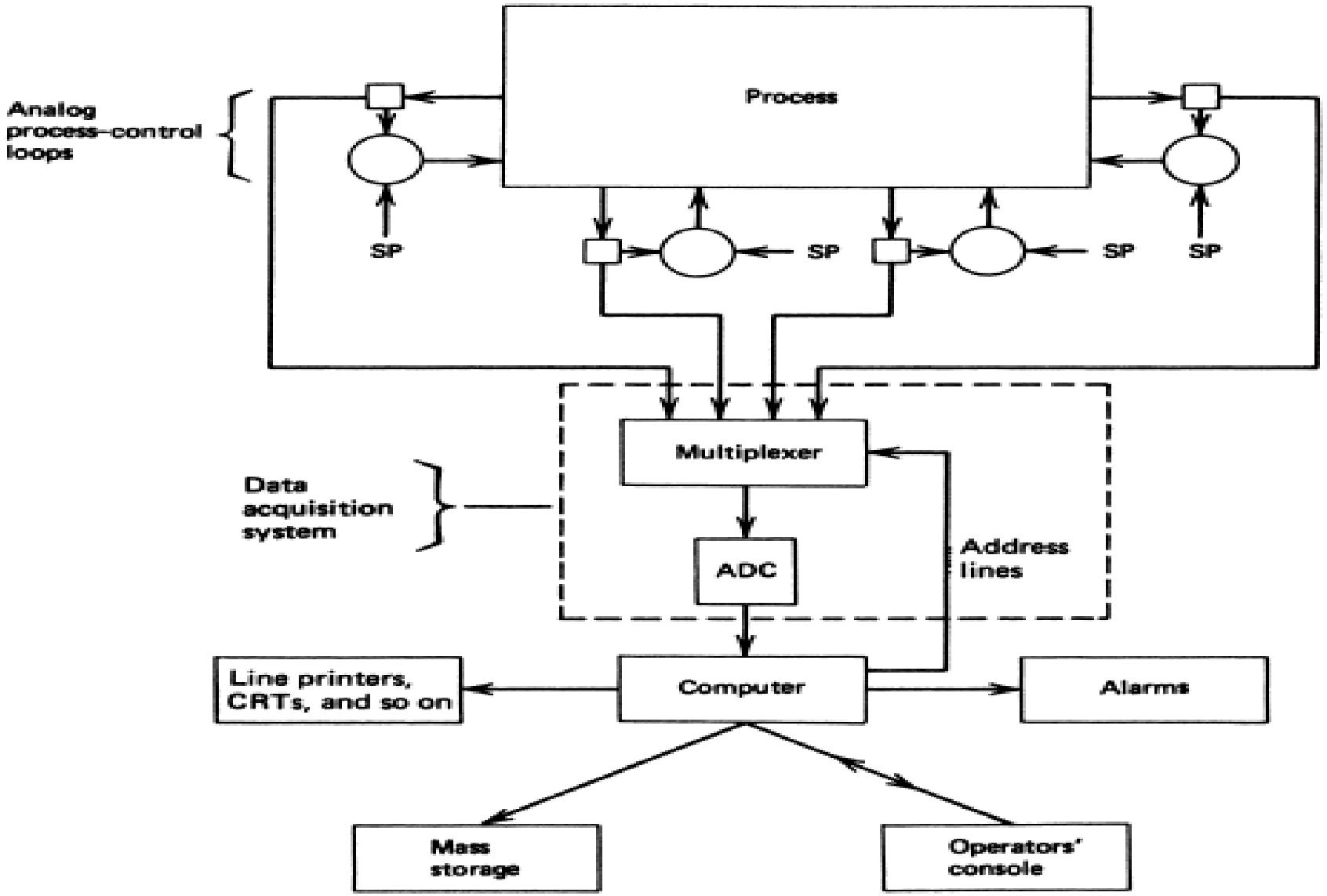
5. Programmer

It controls the sequence of operation of all other units of data logger. It takes information from input scanner, analog to digital converter and recorder. The programmer performs various functions like starting analog to digital conversion, selecting input signal by scanner, recording and displaying reading, resetting logger etc.

6. Clock

The logging sequence is started automatically by a clock. The clock is used to automate the entire data logging system. When the clock signal is generated the scanning operation is started then the data logger advances ahead by time. The clock gives command to the programmer to start logging sequences at the intervals selected by the user.

Fixed Loggers



general features

- Assume the process is under the control of many analog process-control loops and there is provision for analog process variable measurements to be available as a commonly scaled voltage
- Signal conditioning converts all measurements into a given range, often a specified voltage range, as required by a data acquisition system

Data-Acquisition System

The data-acquisition system is the switchyard by which the computer inputs samples of process variable values.

The rate at which samples of a process variable can be taken depends on…

how long it takes for the DAS to acquire a value,

how long it takes the computer to process the value,

and how many other variables are to be sampled

Alarms

- An alarm is defined as an on/off condition wherein a warning is issued when some process variable passes a critical value.
- With scan rates of the data as high as 5000 per second, it is possible for a computer to maintain tight vigilance over variable values.
- Every time the computer inputs a particular variable, the value is compared to its preset limits which, if exceeded, triggers an alarm.

Computer and Peripherals

- Through programming, the computer accepts inputs and performs prescribed reductions of the data through mathematical operations.
- The results are evaluated by further programmed tests to oversee the operation of the entire process from which the inputs are taken
- Projections of future yields, evaluations of efficiency, deviation trends, and many other operations can be performed and made available to process personnel.

- The peripheral units are the support equipment to communicate computer operations to the outside world.

- Peripherals include the *operator console* where the programs are entered and through which commands can be given to initiate specific actions, such as calculations and data outputs by the computer.

- The console usually has a CRT/keyboard and a typewriter unit for input and outputs. A mass-storage system, such as magnetic tape, is used to store data, such as periodically sampled inputs from the process, that can be used in later, more detailed analysis of process performance.

portable data loggers

- There are many cases when data need to be logged for a period of time from a loop and no fixed logger is provided.
- A portable data logger can be temporarily connected to the measurement output of the loop for this purpose.
- In network data communications, the data logger may be connected to a local area network (LAN). The data then can be transmitted over the network to another, fixed computer installation.
- The data can be stored on mass-storage facilities that are part of the network.

portable data loggers

In general, the computer-based portable data loggers have some mechanism for saving

the logged data for later analysis. Possible recording media are

1. Printed output
2. Digitized strip-chart recording
3. Magnetic tape
4. Magnetic floppy disks
5. Networked data communication

Data logging vs data acquisition

- The terms data logging and data acquisition are often used interchangeably. However, in a historical context they are quite different. A data logger is a data acquisition system, but a data acquisition system is not necessarily a data logger.
- Data loggers typically have slower sample rates. A maximum sample rate of 1 Hz may be considered to be very fast for a data logger, yet very slow for a typical data acquisition system.
- Data loggers are implicitly stand-alone devices, while typical data acquisition system must remain tethered to a computer to acquire data. This stand-alone aspect of data loggers implies on-board memory that is used to store acquired data. Sometimes this memory is very large to accommodate many days, or even months, of unattended recording. This memory may be battery-backed static random access memory, flash memory or EEPROM. Earlier data loggers used magnetic tape, punched paper tape, or directly viewable records such as "strip chart recorders".
- Given the extended recording times of data loggers, they typically feature a mechanism to record the date and time in a timestamp to ensure that each recorded data value is associated with a date and time of acquisition in order to produce a sequence of events. As such, data loggers typically employ built-in real-time clocks whose published drift can be an important consideration when choosing between data loggers.

Problem

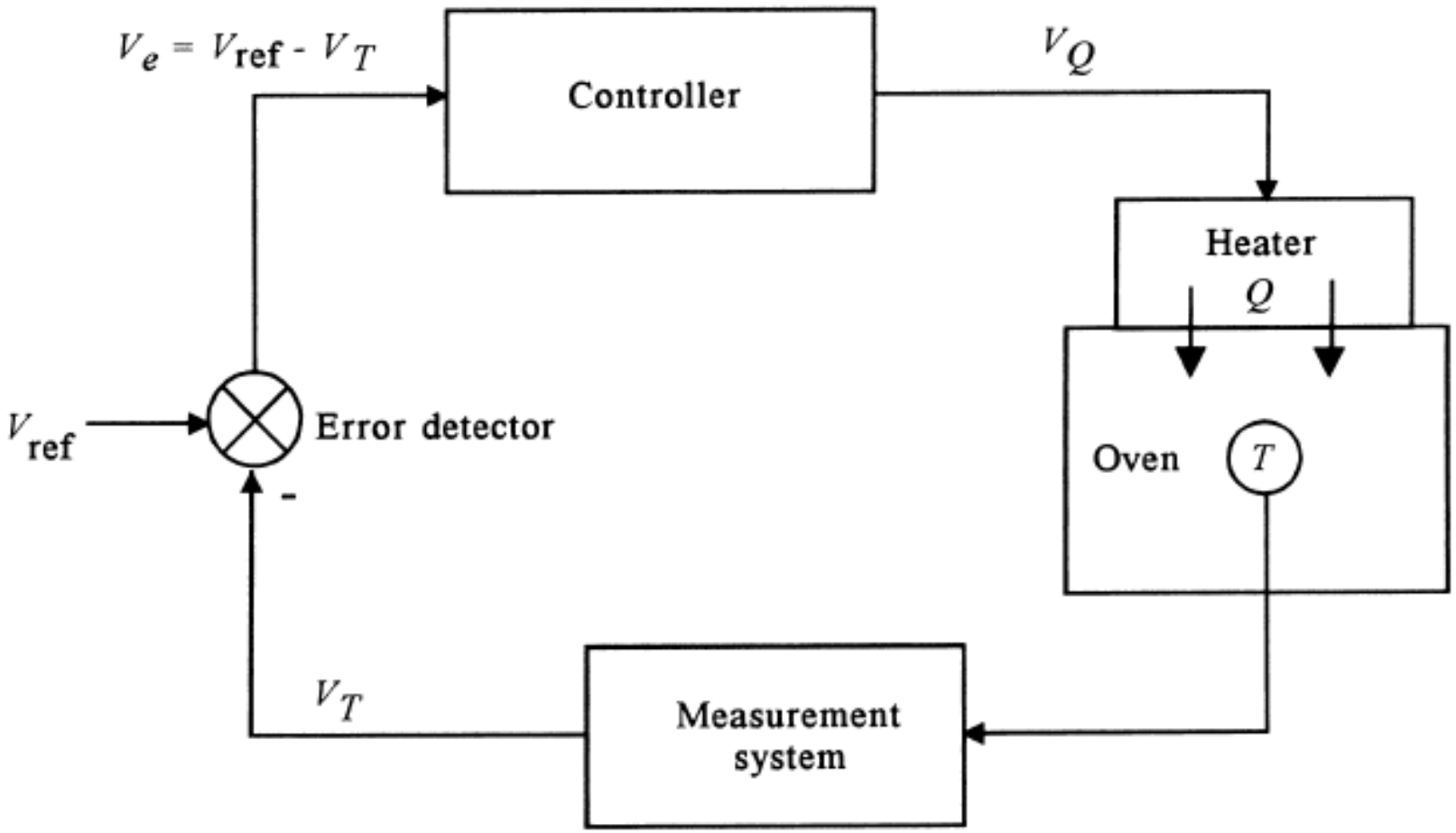
1. A data logging system should monitor 12 analog loops. A small computer requires 4μs per instruction and 100 instructions to address a multiplexer line and to read in and process the data in that line. The ADC performs the conversion in 30 μs. The multiplexer requires 20 μs to select and capture the value of an input line. Calculate the maximum sampling rate of a particular line.

The 100 instructions require a time of $(4\ \mu s)(100) = 400\ \mu s$, and this must be done for 12 loops. Thus, the total instruction time is $(12)(400\ \mu s) = 4800\ \mu s$. The ADC converts in 30 μs, so that for 12 conversions we have $(12)(30\ \mu s) = 360\ \mu s$, and the total time spent in multiplexer switching is 240 μs. Adding $4800 + 360 + 240 = 5400\ \mu s$ as the minimum time before a particular line can be readdressed. The maximum sampling rate is the reciprocal, or 185 samples per second.

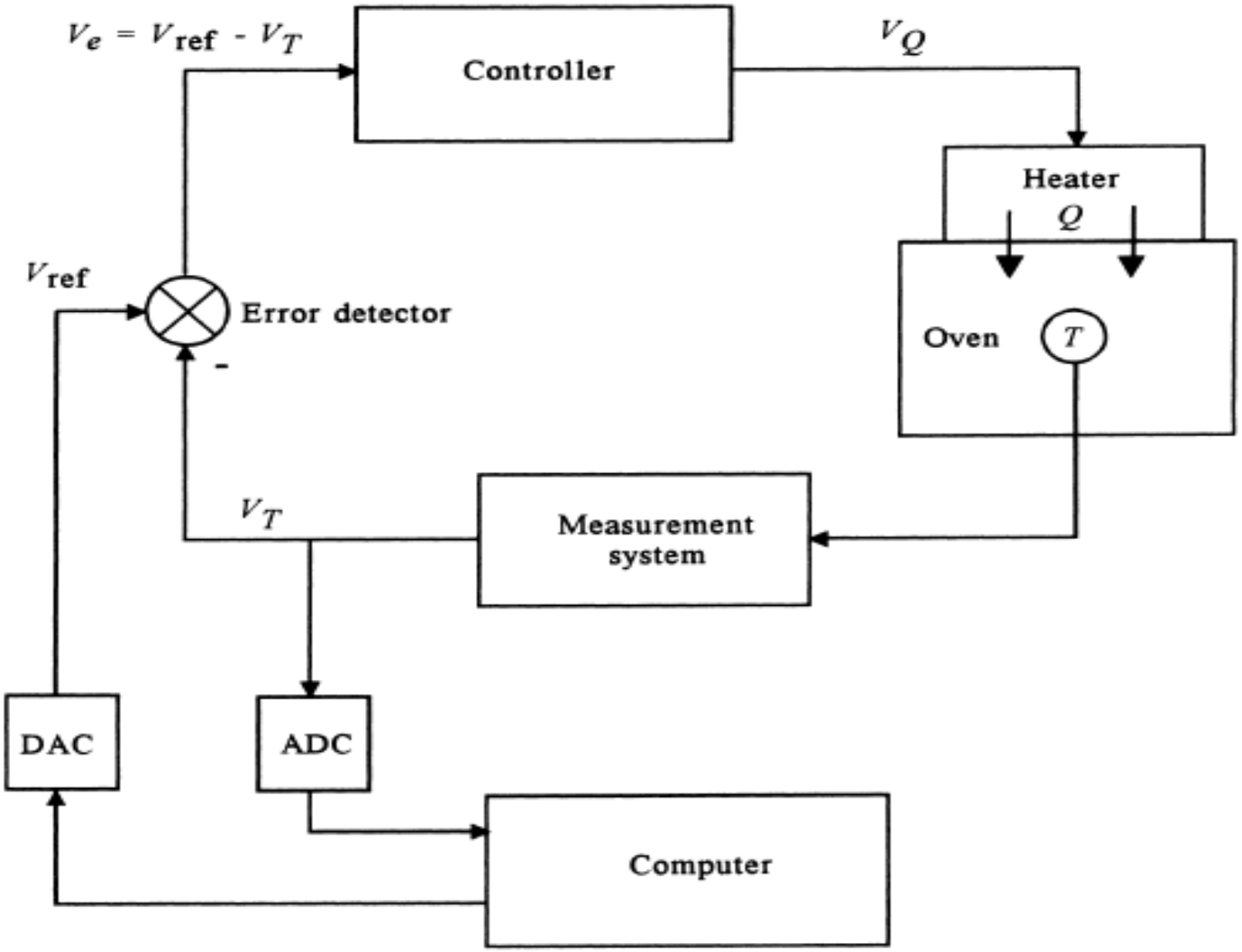
Computer Based Control

- At the heart of nearly all modern control systems is a computer-based controller.
- Here a dedicated computer inputs measurement data, determines the error, performs mathematical operations to determine the feedback, and transmits this feedback to the final control element.
- Such an application is historically referred to as Direct Digital control (DDC).
- It has ability to exchange information between computers over networks – WAN, LAN, etc.

Analog controller



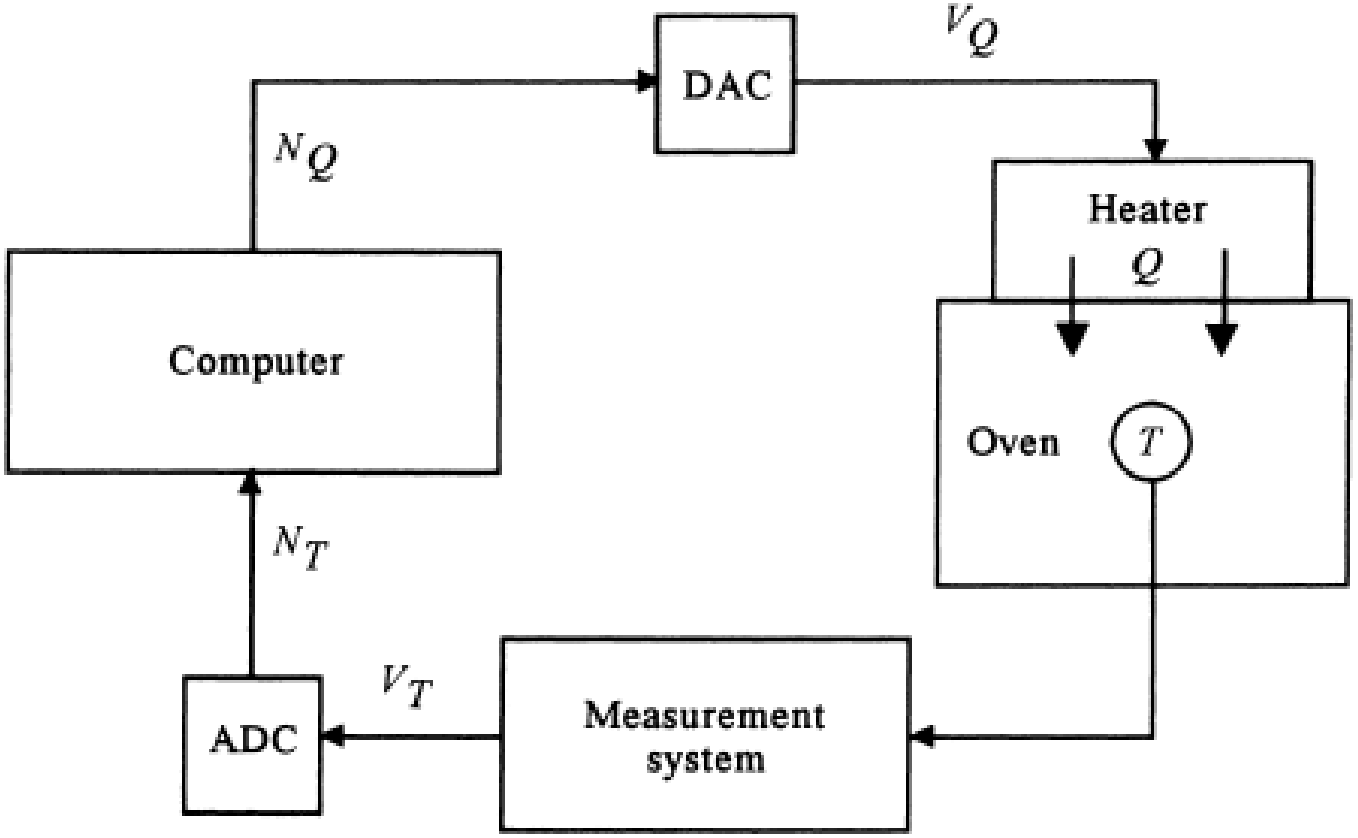
Supervisory control



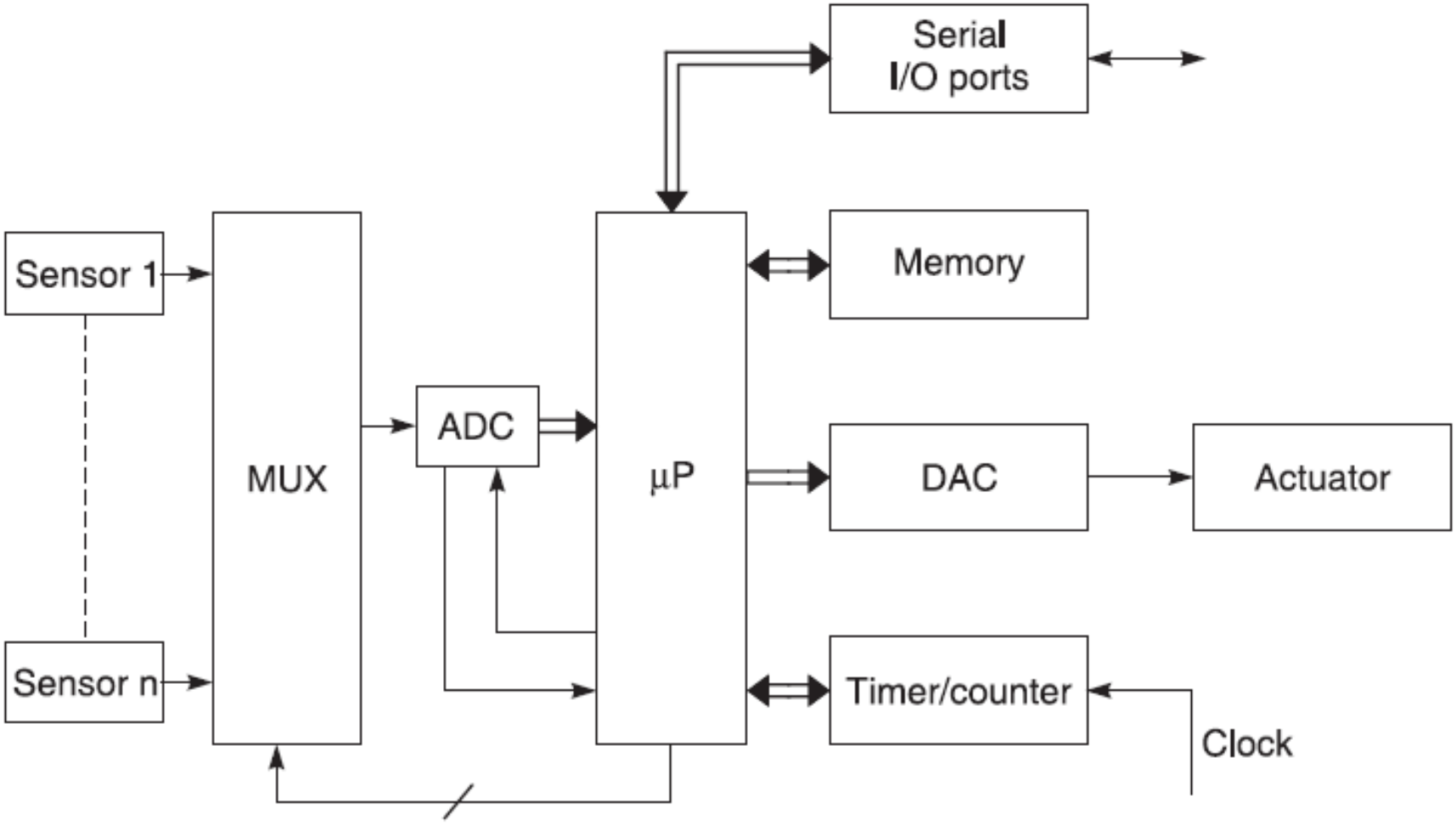
Direct Digital Control (DDC)

- The DDC (Direct Digital Control) directly interfaces to the process for data acquisition and control purpose.
- It should also have memory and arithmetic capability to execute required P, P + I or P + I + D control strategy. At the same time, the interface to control valve should also be part of DDC.
- The multiplexer acts like a switch under microprocessor control. It switches and presents at its output the analog signal from a sensor/transmitter.
- The analog to digital converter converts the analog signal to digital value.

DDC


DAC
V_Q
N_Q
Heater
Q
Computer
Oven
T
N_T
V_T
ADC
Measurement system

DDC


Serial
I/O ports
Sensor 1
Sensor n
MUX
ADC
µP
Memory
DAC
Actuator
Timer/counter
Clock

The microprocessor performs the following tasks.

1. It reads the various process variables from different transmitters through multiplexer and ADC.

2. It determines the error for each control loop and executes control strategy for each loop.

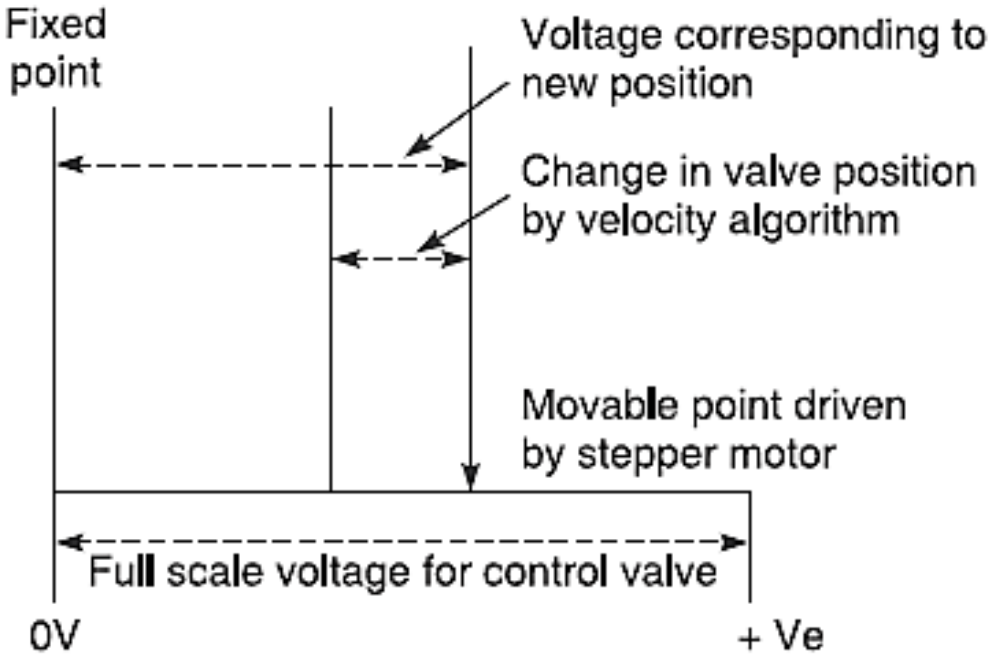
3. It outputs correction value to control valve through DAC.

DDC Software

The main part, DDC software is program for control loops. There are two algorithms for programming a three-mode PID control loop:

— Position algorithm

— Velocity algorithm



References

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- Krishna Kant – Computer based Industrial Control, Prentice Hall, New Delhi ,1997.