CHAPTER 7

DATA ACQUISITION SYSTEM

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7.1 COMPONENTS OF ANALOG AND DIGITAL DATA ACQUISITION SYSTEM

A data acquisition system is a device or an integrated system used to collect information about the state or condition of various parameters of any process. *For example;* collecting day to day temperature of a particular location can be termed data acquisition.

A data acquisition system is used in various applications starting from industry to scientific laboratories. The common definition of data acquisition system is "Data acquisition is the process by which physical phenomena from the real world are transformed into electrical signals that are measured and converted into a digital format for processing, analyzing and storage by a computer".

The basic elements of a data acquisition system are,

i) Sensors and transducers

ii) Field wiring

iii) Signal conditioning
iv) Data acquisition hardware
v) PC (operating system)
vi) Data acquisition software

7.1.1 Components of an Analog Data Acquisition System

An analog data acquisition system typically consists of some or all of the following elements.

a) Transducers

Transducers is a device that converts energy from one form to another. It is desirable that an emf obtained from the transducer potential to the quantity being measured, is used as an input to the data acquisition system. Therefore, transducers such as thermocouples, strain gauge bridge, piezo-electric devices are used.

As an exception to this usual function of transducers, some sensors produce a frequency which can be counted with an electronic counter to obtain the integral of the measured quantity or it can modulate a telemetering transmitter and can be reduced to a voltage with the help of a discriminator.

b) Signal conditioning equipment

Signal conditioning equipment includes any equipment that assists in transforming the output of transducers to the desired magnitude or form required by the next stage of the data acquisition system. It also produces the required conditions in the transducers so that they work properly signal conditioners may include devices for amplifying refining or selecting certain portions of these signals.

c) Calibrating equipment

Before each test, there is a precalibration and often after each test there is a postcalibration. This usually consists of a millivolt calibration of all input circuits and shunt calibration of all bridge type transducer circuits.

d) Integrating equipment

It is often desirable to know the integral or summation of a quantity. There are several ways of determining the time integral of quantity. An analog integrating circuit can be used for a qualitative test. It has the possible danger of becoming over loaded and also its accuracy is low. Hence, digital techniques are normally used for integrating purposes.

e) Visual display device

Visual display devices are required for continuous monitoring of the input signals. These devices include panel mounted meters, numerical displays, single or multichannel CROS and storage type CROS etc

f) Analog recorders

Analog recorders include strip chart recorders, Duddell's oscillograph, magnetic tape recorders and CRO with photographic equipment.

g) Analog computers

The function of a data acquisition system is not only to record data acquired by the transducers and the sensors but also to reduce this data to the desired form. An analog computer may be used as a data reduction device. The output voltage of an analog computer can either be recorded in analog form or be converted to a digital form for recording and further computations.

h) High speed cameras and TV equipment

In many industrial processes, engine testing and aerodynamic testing, it is not possible for the test operator to have a view of the equipment being tested. Therefore closed circuit TV is used to enable the operator to speed cameras are employed to obtain a complete visual record of the process for further analysis.

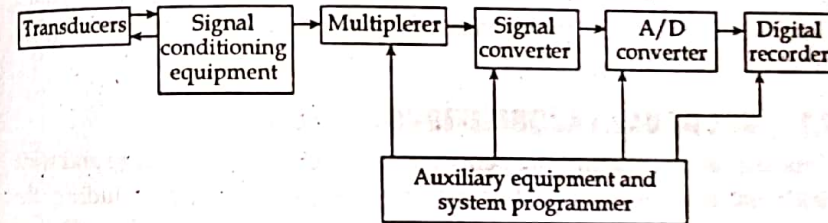### 7.1.2 Components of a Digital Data Acquisition System

Figure: Components of digital data acquisition system

The various components and their functions are:

a) Transducer

It convert a physical quantity to an electrical signal which is acceptable by the acquisition system

b) Signal conditioning equipment

It deals same function as in analog data acquisition system.

c) Multiplexer

Multiplexing is the process of sharing a single channel with more than one input. Thus a multiplexer accepts multiple analog inputs and connects them sequentially to one measuring instrument.

d. Signal converter

A signal converter translates the analog signal to a form acceptable by the analog to digital converter.

e) Analog to digital converter

An analog to digital converter converts the analog voltage to its equivalent digital form. The output of the A/D converter may be fed to digital display devices for visual display or may be fed to digital recorders for recording. It may be fed to a digital computer for data reduction and further processing.

f)   Auxiliary equipment

This contains device for system of the typical functions done by auxiliary equipment are linearization and limit comparison of signals. These functions may be performed by individual devices or by a digital computer.

g)   Digital recorders

Records of information in digital form may be done on punched cards, perforated paper types, type written page or magnetic tape or a combination of these systems.

h)   Digital printers

After all the tests have been completed and the data generated, it becomes necessary to record the numbers and in some case reduce the data to a more meaningful form a digital printer can be specified to interface with an electronic instrumentation system in order to perform this work, and thus provides a high quality hardcopy for records and minimizing the labor of the operating staffs.

7.2   USE OF DATA ACQUISITIONS SYSTEMS

Data acquisition systems are being used in ever increasing large and wide fields in a variety of industrial and scientific areas, including the aerospace, bio medical and telemetry industries. The type of data acquisition system to be used depends upon the application and the intended use of recorded input type.

Analog data acquisition systems are used when wide frequency width is required or when lower accuracies can be tolerated. Digital data acquisition systems are used when the physical quantity being monitored has a narrow bandwidth (i.e., when the quantity varies slowly). Digital system are also used when high accuracy and low cost per channel is required.
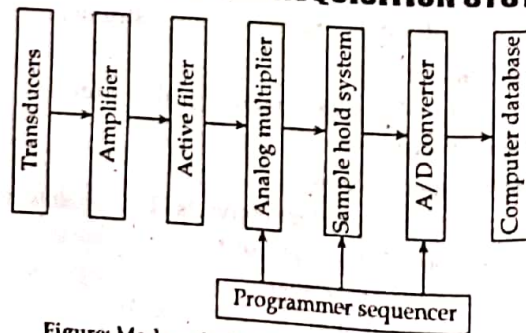
7.3   MODERN TRENDS IN DATA ACQUISITION SYSTEM

Figure: Modern digital data acquisition system

The components of modern digital data acquisition system are,

a)   Transducer

The input to the system is a physical parameter such as temperature, pressure, flow, acceleration or position which are analog quantities, the parameters is first converted into an electrical signal by means of a transducer; once in electrical form all further processing is done by electronic circuits.

b)   Amplifier

The amplifier or signal conditioner boosts the amplitude of the transducer output signal to a useful level for further processing. Transducer outputs may be microvolt or millivolt level signals which are then amplified to 1 to 10 V levels. Furthermore, the transducer output may be impedance signal, a differential signal with common mode noise, a current output, a signal superimposed on a high voltage or a combination of these. The amplifier, in order to convert such signals into a high level voltage may be one of the several specialized types.

c)   Active filter

The amplifier is frequently followed by a low pass filter which reduces high frequency signal components, unwanted electrical noise or electronic noise from the signal. The amplifier is sometimes also followed by a special nonlinear analog function circuit that performs a non-linear operation on the high level signal.

d)   Analog multiplexer

The processed analog signal next goes to an analog multiplexer, which sequentially switches between a number of different analog input channels. Each input is in turn connected to the input of the multiplexer for specified period of time by the multiplexer switch. During this connection time, a sample-hold circuit acquires the signal voltage and then holds its value while an analog to digital converter converts the value into digital form. The resultant digital word goes to a computer data bus or to the input of a digital circuit.

e)   Sample and hold system, A/D converter and computer database

The analog multiplexer, together with the sample-hold time shares the A/D converter with a number of analog input channels. The timing and control of the complete data acquisition system is done by a digital circuit called a programmer-sequencer which intern is under control of the computer. In some cases, the computer itself may control the entire data – acquisition system.

7.4 BOARD EXAM QUESTIONS SOLUTION

1. What is data acquisition system? [2011/F, 2013/F, 2013/S, 2014/S, 2015/F, 2017/F, 2017/S, 2018/S, 2019/F]

Solution: See the definition of 7.1.

2. Explain, in brief about the analog data acquisition technique. [2011/F, 2012/F, 2012/S, 2018/S]

Solution: See the definition of 7.1.1.

3. Explain the different components of modern digital data acquisition theorem. [2011/S]

OR Explain in brief about modern trends used in data acquisition system. [2014/S, 2016/S, 2018/F]

Solution: See the definition of 7.3.

4. Briefly explain about the digital data acquisition system. [2012/S, 2013/S, 2014/F, 2015/F, 2016/F, 2017/F, 2018/F, 2019/F]

Solution: See the definition of 7.1.2.

5. What are the uses of data acquisition system? [2015/S]

Solution: See the definition of 7.2.

6. Differentiate between analog DAS and digital DAS. [2013/F, 2017/S]

Analog DAS	Digital DAS
a) The basic components used in the analog DAS are, i) Transducer ii) Signal conditioner iii) Multiplexers iv) Calibrating equipment v) Integrating equipment vi) Visual display device vii) Analog recorders viii) Analog computers	The basic components used in the digital DAS are, i) Transducers ii) Signal conditioner iii) Multiplexers iv) Signal converters v) Analog to digital converter vi) Auxiliary equipment vii) Digital recorders viii) Digital printers
b) No need of signal conversion	Signal conversion is needed to convert analog signal to a suitable form that is acceptable by A/D converter
c) Analog DAS are not complex comparing with digital DAS.	Digital DAS are more complex in terms of circuit involved and complexity of input data they can handle.
d) Analog DAS are used when wide bandwidth is required or when lower accuracy can be tolerated.	Digital DAS are used when physical quantity being monitored has a narrow bandwidth.
e) It has relatively less accuracy than digital DAS.	It has relatively high accuracy than analog DAS.
f) It has high cost per channel.	It has low cost per channel.