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DATA ACQUISITION SYSTEMS :A STUDY

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Introduction

This Paper will take an in-depth information look at data acquisition systems.

1. Principles of Data Acquisition Systems

A data acquisition system is a system that comprises sensors, measurement devices, and a computer. A data acquisition system is used for processing acquired data, which involves collecting the information required to understand electrical or physical phenomena.

Figure 1.1: Data Acquisition Systems

This information is required for understanding how a data acquisition system performs. As an example, a data acquisition system can be used when testing the temperature of a heating coil used for heating an object to a specific temperature. The level of success of the heating coil is understood by measuring its temperature. That simple task of measuring and recording temperature is called data acquisition and is achieved using a data acquisition system. Another example where a data acquisition system comes into play is when measuring and recording the potential difference in current flow across an electrical resistor.

The reason for measuring and recording the electrical and physical phenomena using a data acquisition system is to enable further analysis. A data acquisition system uses software to perform its functions and it is capable of quickly processing and storing data in many ways. Data acquisition systems can capture data from an actual system and store the data in a simple format that is easily retrievable for further engineering or scientific review.

Data acquisition systems are either handheld, or they can be remotely operated. Handheld data acquisition systems are used when there is a requirement for taking readings of a specimen which can be physically interacted with. When direct human interaction with an object is not possible or necessary, this is when remote data acquisition systems are used to take remote DAQ (data acquisition) measurements.

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1.1 Basic Components of a Data Acquisition System

The physical phenomena or physical characteristics to be measured comes first in the data collecting process. Temperature, light intensity, vibration, gas pressure, fluid movement, and force are a few examples of factors often considered in a DAQ system. No matter what kind of physical property has to be measured, the physical state must first be unified into a form that a data acquisition system can sample.

These alterations are carried out by sensors. An ensemble of software and hardware known as a data acquisition system enables the measurement or control of physical properties of objects in the real world. A full data acquisition system consists of DAQ hardware, sensors, actuators, signal conditioning gear, and a computer running DAQ software. Furthermore, an independent timing system must be used if timing is important (for example, in event mode DAQ systems)

Figure 1.2: Data Acquisition System Components

a. Sensors

Sensors or transducers serve the purpose of interacting with the subject measured. They interact with the subject either directly or indirectly, or as defined in other words, contact or non-contact. These tools convert the physical values to produce an output of electrical signals. There are many different types of sensors that are utilized in data acquisition systems depending on the nature of their application. For instance, when the temperature is being measured, a temperature sensor is used, but when measuring light, a photovoltaic sensor is used.

Figure 1.3: Data Acquisition System Sensors

These tools both have a common function of converting analog signals like temperatures, light, speed, etc. into digital signals that are compatible with a computer. The sensors utilized by DAQ systems are high-quality sensors that are capable of giving accurate readings with minimal or no noise.

b. Transmission/Signal Conditioners

The electrical signals obtained from the sensors may contain noise or other interference and need modification; they could not be used directly as is. The signals might also be weak to a point where the data acquisition system cannot measure them. Hence additional circuitry is utilized for optimizing the signals. This additional circuitry is known as a signal conditioner. Signal conditioning then is the process of optimizing the signals.

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Figure 1.4: Components of a Data Acquisition System

The signal conditioner makes use of filter circuits for separating the noise from the real signal and utilizes an amplification circuit for strengthening weak signals. These are two of the most common functions that are served by the transmission or signal conditioners. A suitable signal conditioning circuit can achieve additional processes like linearization, calibration, and excitation. The selection of the signal conditioning circuit is largely dependent on the characteristics of the sensors employed in the DAQ system.

c. Data Acquisition Hardware

Data acquisition hardware is the hardware that is connected between the sensors and the computer. This hardware is either connected to the computer employing a USB port or through the PCI-express ports that are found on the motherboard. The data acquisition hardware serves to take in the signals from the sensors and then convert them into digital signals that are readable by the computer. This is the function that DAQ hardware performs.

d. Analog-to-Digital Converters

This component of the DAQ system serves to convert analog signals into digital signals. This component is at the core of all data acquisition systems. This chip serves to take data from the environment and convert it into separate levels that can be interpreted by a processor. These distinct levels correspond to the smallest detectable change that can be found in the measured signal.

The higher the number of bits of an analog to digital converter, the greater the number of discrete levels that can be used for representing an analog signal, and the greater the resolution of the analog to the digital converter. The resolution of an analog to digital converter is essentially comparable to the marks that are found on a measuring stick.

Using a metric measuring stick, a measuring stick that has mm marks has greater resolution than that with only cm marks; here in the United States, a yardstick featuring the specific inches would show greater resolution than one only broken down by individual feet. The need for mm or cm depends on what is being measured – the same is true for analog to digital converter resolution.

e. Digital-to-Analog Converters

The function of this component of a DAQ system is to provide support for inputting, as well as outputting, binary signals.

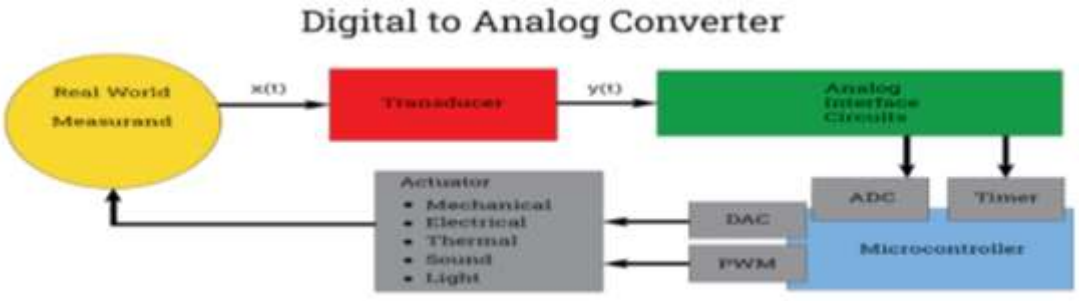

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Figure 1.5: Digital to Analog Converter

2. Data Acquisition Systems Measurements, Modules & Methods

2.1 Data Acquisition Systems Measurements

Data acquisition systems are capable of making many different types of measurements. These types of measurements are typically derived from analog signals. Before their transfer into any computer system, they must be in a digital format.

Many different parameters can be measured using a data acquisition system including the following:

Current, Voltage, Strain, Frequency or time interval, Pressure, Temperature, Distance, Vibration, Angles, Digital signals, Weight.

Separate modules or sensors may be utilized for measuring different, specific parameters, although several multi-input, general-purpose data acquisition devices can interface to these various sensors. The types of sensors that are utilized in data acquisition measurements usually return values of voltage in particular since these readings can be converted into measurements of temperature, displacement, or anything that is being studied.

Often a data acquisition module, as well as a sensor, will make use of a transducer of some kind in order to create a base measurement parameter- like voltage. This measurement is known as the primary measurement. It will then be converted into subsequent parameters as required. In this way, data acquisition modules are capable of measuring almost any required parameters which may need to be made or obtained.

2.2 Data Acquisition Cards and Modules

Many data acquisition systems have rack modules that are filled with cards for providing the different measurement functions that are needed. These cards obviously must conform to the overall system that is utilized in both electrical and mechanical interfaces. The rack systems used are often standardized and the modules employed are often available from many manufacturers, thereby making their selection more convenient.

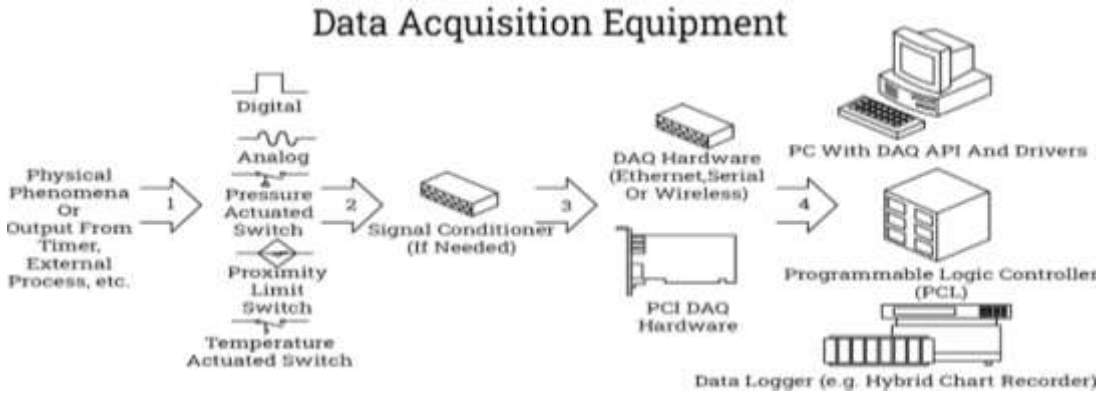

Figure 2.1: Data Acquisition Equipment

a. Data Acquisition Software

Specialized data acquisition software required for acquiring, storing, and processing data in a logical format is available. Software used in data acquisition systems can be written in various languages and can be written for a specific application in mind. Alternatively, there are many different data acquisition software packages available that can be utilized instead.

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The benefit of proprietary data acquisition software packages is that all of the development has already been undertaken and the system has already been deployed; therefore, most problems have already been encountered. Even though a charge for the software maintenance is applicable, this will be considerably less than trying to do maintenance on a similar home-grown data acquisition software package.

Accordingly, most companies choose to buy their data acquisition software and then utilize this in developing tests for their own particular use.

b. Data Acquisition Transducer Signals

Transducers are the electronic devices that change energy from a particular source into an electronic signal. Depending on the specific variable that the DAQ system is designed to measure, the output signal varies. Data acquisition systems are usually discussed in terms of the output signal they generate. The output signal generated may be digital or analog.

2.3 Data Acquisition Methods Used by DAQ Systems

Some of the data acquisition techniques include:

a. Bit-Stream Disk-to-Image File

This is a data acquisition method used in some very specific data acquisition systems. This method is mostly utilized by forensic investigators. It is a flexible method of data acquisition, and it allows the creation of one or more copies of an original drive. More importantly, it also copies everything from the original drive, including interconnected sectors or clusters, in order to retrieve files that were subsequently deleted or tampered with. Some popular tools used for reading the disk-to-image files include EnCase, X-Ways, FTK, ILook Investigator, etc.

b. Bit-Stream Disk-to-Disk

Sometimes, when the creation of a bit-stream disk-to-image file is not possible due to software or hardware errors or other incompatibilities, a bit-stream disk-to-disk method is used instead. When investigators face such issues mentioned above while they try to acquire data from older drives, they create a bit-stream disk-to-disk copy of the original drive or disk. The tools that are used to create the disk-to-disk bit-stream copy of an original tampered drive include EnCase, Safe Back, as well as Norton Ghost. These tools are capable of modifying the target disk's geometry for matching the data copied from the original suspect drive.

c. Logical Acquisition

This method is used for gathering only the files that are required for an individual case investigation. For example, the collection of Outlook .ost or .pst files in email investigations, and the collection of specific records from a large RAID server would be utilized through this procedure.

d. Sparse Acquisition

This method is similar to logical acquisition. With this method, investigators are capable of collecting fragments of unallocated data. This method is mostly used when there is no necessity of inspecting the whole drive.

2.4 Considerations When setting up a Data Acquisition System

Some of the considerations when setting up data acquisition systems include:

a. Runtime Without Interruption

Prior to anything else, you must be certain of how long you want the system to operate without interruption. The choice of hardware and operating system will be significantly influenced by this period of time. Additionally, there is a great likelihood that the data flow may become backed up, along with subsequent errors resulting, due to buffer overflow if the processor is under stress from having to keep up with the tasks continually. The system's hard

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drive and battery will begin to wear down, eventually stopping after a decade or sooner. Therefore, the first factor to take into account when considering a DAQ system is the length of time you'll want the system to operate. Only then, will you be able to move on to consider the other things you'll need to think about (as listed below) when choosing the best option for your needs.

b. Power Source

The power source is the next item to think about. You must determine if the system will have access to a reliable power supply or if the DAQ system will require a secondary power source. Choosing a secondary source is obviously less of an issue the more reliable the primary power source may be. Some common back-up power sources include generators, batteries or solar panels. Where multiple, reliable energy sources are available, performing power calculations is advisable; when doing so, it is best to be cautious and monitor power when working under actual conditions.

c. Data Transmission

The transfer of data from the system should be taken into account next. You must determine if the data collection system requires local data storage or remote data transmission of data from the field or the facility. Additionally, you must choose the system based on how much storage you will need. Furthermore, you must decide if you want the system to still have the ability to store and forward data in order to buffer the collected data while the link is unavailable, and continue sending when it becomes accessible.

d. System Access

You must be explicit when setting up a data acquisition system on whether you will require remote access before you configure the system or determine if it is functioning properly. In today's work-from-home environment, it is advisable to build up a system for data collection that can be accessible from a distance. Additionally, it is possible that you may require access to the system in order to change the system's acquisition parameters itself.

e. Data Acquisition and Data Processing

When setting up a data acquisition system, you must decide in advance whether you merely need to gather raw data or whether you need to treat the data in a certain way after the acquisition process. When choosing the best data collecting system, this issue must be taken into account. A straightforward system would be enough if all you needed to do was collect data from the process. However, a CPU would be necessary in the system if you needed it to execute some specialized functions, such as filtering, Windowing, and other operations.

f. Input Channels

Finally, you must examine your input channel. You must be certain of the effectiveness of your input channel. The main elements to take into account in this case are the sample rates, the data to be obtained from the signals, the synchronization of signals, and the range of signals considered. Taking into account each of these aspects will help you select the best data collecting system for your needs.

3. Applications and Benefits of Data Acquisition Systems

3.1 Applications of Data Acquisition Systems

Electronics, Automotive Industry, Imaging, Laser Technology, Sonar-Radar, Industrial Machines, Non-Destructive Testing.

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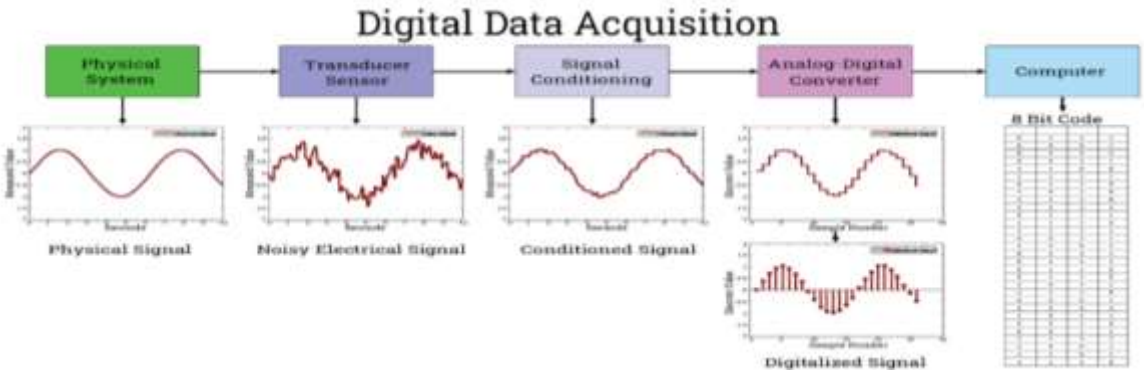

Figure 4.1: Digital Data Acquisition

3.2 Benefits of Data Acquisition Systems

The advantages of data acquisition systems include:

Accuracy, Scalable, High Efficiency and Reliability of Processes, Faster Analysis and Resolution of Problems, Decrease in Update Errors, Improved Integration of Data, Through Less Reliance on Other Programs, Improved Access to Data for Users, Supervision of Processes without Human Interaction, Improved Data Security, Cost-Effectiveness, Quality Control Data Acquisition Systems are Highly Versatile, Better File Processing and Transfer Capabilities

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4 Conclusion

Data acquisition systems are a process for capturing, storing, analysing, and manipulating data. The data is acquired through different techniques including voltage signals, current signals, power signals, etc. There are different types of data acquisition systems utilized. Some of them are multipurpose devices with an all-in-one configuration whereas some are single-purpose devices designed for measuring data from single parameters. Data acquisition systems can be applied in a wide variety of industries including the automobile industry, the electronics industry, laser technology, etc. These systems offer so many benefits. They are cost-effective, fast, versatile, and reliable. Data acquisition systems are a very efficient and convenient way of recording data for further analysis. Data acquisition systems not only improve data security since the process of capturing data is now automated, they improve access to data for the users while reducing errors.

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