PRESENTATION

DATA ACQUISITION AND CONTROL SYSTEMS

The topic of presentation is : Data acquisition and control systems

INTRODUCTION

- BRANCH OF TEST AND MEASUREMENT
- CONVERTING ANALOG SIGNALS INTO DIGITAL DATA
- STREAMING THE DATA TO A COMPUTER

Data acquisition is a branch of test and measurement distinguished by converting analog signals into digital data and then streaming the data to a computer. Because a data acquisition system can leverage the processing power and user interface of an attached PC, such systems typically cost less than stand-alone test equipment offering comparable performance. The engineers and researchers who use PC-based data acquisition systems also benefit from software, which can display data graphically, in real time, or perform on-the-spot analysis.

FUNCTIONS

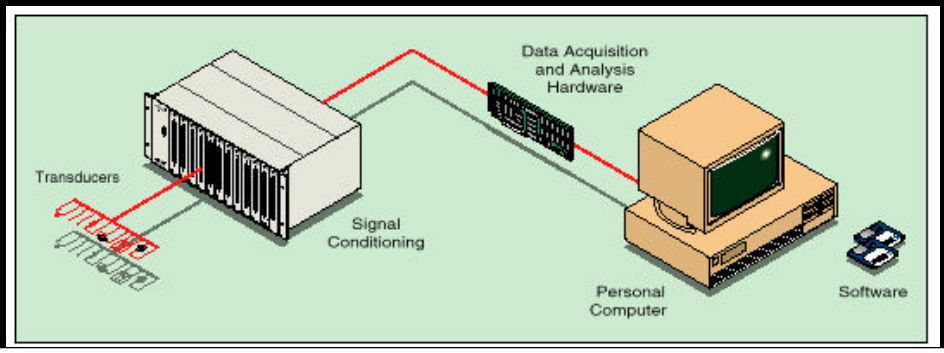
- **Sense physical variables such as pressure, temperature, flow, and motion**
- **Use signal conditioning to make unusual signals readable by Analog Input Boards**
- **Using Analog to digital boards to convert the signal into a digital format acceptable by the PC**
- **Process, analyze, log to the hard disk, and provide a graphical display of the data acquired by your PC with the help of software**
- **Provide an appropriate control response to influence the process**

Some of the important functions of data acquisition are to:-

- Sense physical variables such as pressure, temperature, flow, and motion
- Use signal conditioning to make unusual signals readable by Analog Input Boards
- Using Analog to digital boards to convert the signal into a digital format acceptable by the PC
- Process, analyze, log to the hard disk, and provide a graphical display of the data acquired by your PC with the help of software
- Provide an appropriate control response to influence the process

THE TYPICAL DAQ SYSTEM

- PERSONAL COMPUTER
- TRANSDUCERS
- SIGNAL CONDITIONING
- DAQ HARDWARE
- SOFTWARE



Today, most scientists and engineers are using personal computers with expansion buses for laboratory research, industrial control, and test and measurement. Obtaining proper results from a PC-based DAQ system depends on the following elements of a typical data acquisition system:-

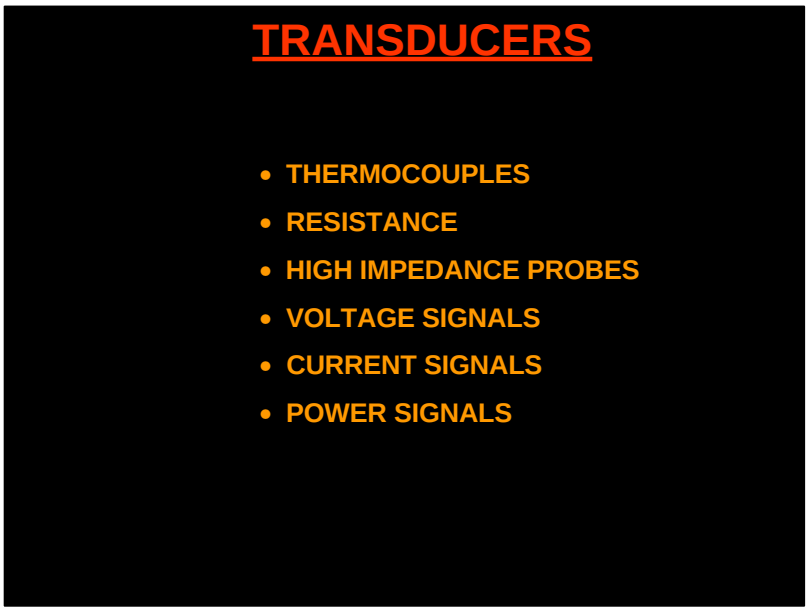
- Personal computer
- Transducers
- Signal conditioning
- DAQ hardware
- Software

PERSONAL COMPUTER

The personal computer has become the most popular platform for data acquisition. PCs are so abundant in the workplace now that it's hard to find a business that doesn't use them. And since the ISA/PCI bus allow the user to add lots of expansion cards, thousands have added inexpensive plug-in data acquisition cards to their desktop PCs. Using a PC for data acquisition needs just makes sense. PCs have been declining in cost for years, all the while becoming faster and more powerful. Now, there simply is not a more cost-effective platform. What's more, many people in the workplace have considerable experience working with PCs, so in most cases there is a very short learning curve.

The PC's open architecture allows the user the flexibility to configure almost any system imaginable. Its immense popularity has created widespread support by vendors of every kind, so finding the peripherals and software to do exactly what you need is easy. As more and more standards are being developed, compatibility between different vendors' cards and peripherals is becoming less and less of an issue.

As PCs have become more powerful and robust, it has become easy to overcome the limitations that used to keep people from considering the PC for a data acquisition platform. PC-based systems aren't limited to plug-in boards anymore. With the advent of portable and notebook PCs, a variety of portable data acquisition systems have emerged. You can perform any and all of the analog and digital I/O conventionally done on the ISA or PCI bus through your PC's parallel port, serial port or PCMCIA slot.



Transducers are devices that convert one type of physical phenomenon, such as temperature, strain, pressure, or light, into another. The most common transducers convert physical quantities to electrical quantities, such as voltage or resistance.. For example, thermocouples, RTDs(resistance temperature detectors) , thermistors, and IC sensors convert temperature into a voltage or resistance. Other examples include strain gauges, flow transducers, and pressure transducers, which convert force, rate of flow, and pressure to electrical signals. In each case, the electrical signals produced are proportional to the physical parameters they are monitoring.Some coomon transducers are:-

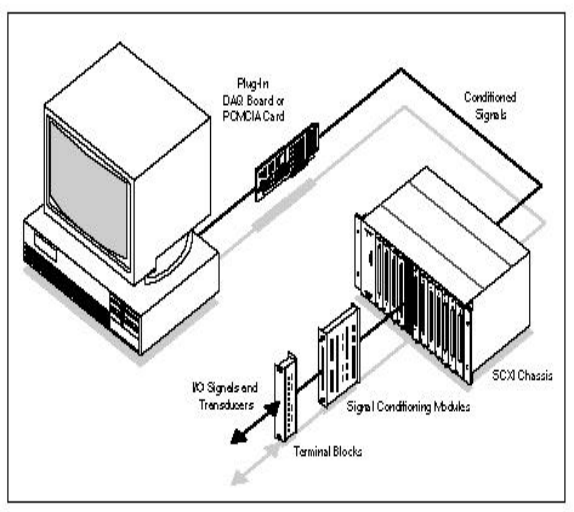
- Thermocouples for temperature measurement
- Resistance for temperature, displacement and light level measurement
- High Impedance Probes for concentration measurement
- Voltage Signals for voltage, conditioned transducer, level and flow measurement
- Current Signals for current and conditioned transducer measurement
- Power Signals for power supply, current and voltage measurement
- Strain guage bridges for strain measurement
- Excitation for force, pressure, relative humidity, temperature, level, light level, concentration and vibration measurement
- LVDTs (Linear Variable Displacement Transducers) for displacement measurement
- Encoders for angular position measurement
- Counter-Timers for speed and flow measurement
- Digital Signals are used for on/off measurements

TRANSDUCERS

- STRAIN GUAGE BRIDGES
- EXCITATION
- LVDTS
- ENCODERS
- COUNTER-TIMERS
- DIGITAL SIGNALS

SIGNAL CONDITIONING

- AMPLIFICATION
- FILTERING
- ISOLATION
- MULTIPLEXING
- EXCITATION
- LINEARIZATION



Transducer outputs must often be conditioned to provide signals suitable for the DAQ board. Signal conditioning accessories amplify low-level signals, isolate, filter, excite, and bridge transducers to produce high level signals for the DAQ board. Regardless of the types of sensors or transducers being used , the proper signal conditioning equipment can improve the quality and performance of the system. Signal conditioning functions are useful for all types of signals.Digital signals also require signal conditioning.Digital signals are usually not directly connected when used in research and industrial environments to a DAQ board without some type of isolation because of the possibility of large voltage spikes or large common-mode voltages. Some signal conditioning modules and boards optically isolate the digital I/O signals to remove these problems. Digital I/O signals can control electromechanical or solid-state relays to switch loads such as solenoids, lights, motors, and so on. In addition, many transducers require excitation currents or voltages, bridge completion, linearization, or high amplification for proper and accurate operation. Therefore, most PC-based DAQ systems include the following form of signal conditioning in addition to the plug-in DAQ board and personal computer.

Amplification - Unwanted noise can play havoc with the measurement accuracy of a PC-based DAQ system. The effects of system noise on measurements can be extreme if proper care is not taken. Signal conditioning circuitry with amplification, which applies gain outside of the PC chassis and near the signal source, can increase measurement resolution and effectively reduce the effects of noise.

Filtering - Filtering removes unwanted signals from the signal that are being measured. A noise filter is used on DC-class signals such as temperature to attenuate higher frequency signals that can reduce the accuracy of measurement. Specific filters can reject unwanted noise within a certain frequency range. Many systems will exhibit 50 Hz periodic noise components from sources such as power supplies or machinery. Low-pass filters on signal conditioning circuitry can eliminate unwanted high-frequency components. However, the filter bandwidth is to be carefully selected so that it does not affect the time response of desired signals.

Isolation - Another common application for signal conditioning is to isolate the transducer signals from the computer for safety purposes. The system being monitored may contain high-voltage transients that could damage the computer. An additional reason for needing isolation is to make sure that the readings from the plug-in DAQ board are not affected by differences in ground potentials or common-mode voltages.

Multiplexing – A common technique for measuring several signals with a single measuring device is multiplexing.Signal conditioning devices for analog signals often provide multiplexing for use with slowly changing signals such as temperature .

Excitation – Signal conditioning also generates excitation for some transducers. Strain gauges, thermistors, and RTDs , for example , require external voltage or current exci ta t ion signals .

Linearization – Another common signal conditioning function is linearization. Many transducers , such as thermocouples , have a nonlinear response to changes in the phenomena being measured.

In general terms data cquisition hardware can be classified in the following three categories:-

Analog Input/Outputs

An analog signal is a continuous-time function with a physical parameter defined for every instance of time. This signal must be converted into a discrete-time signal so that it can be used by the computer to depict the original signal. Analog to Digital conversion is a ratio operation, where the input signal is compared to a reference, and converted into a fraction, which is then represented as a coded digital number. To optimize measurement accuracy, there is a minimum and a maximum number of data points that need to be acquired.Analog outputs are used by the interface to provide DC voltage levels or arbitrary waveforms. The output levels are set by a D-to-A converter. Bipolar D/A converters output voltages that are with respect to a reference voltage. Unipolar D-to-A converters output voltages that range from 0 to the reference voltage. In either case the D/A converter outputs the fraction of the reference voltage that the digital word represents.

Digital I/O

The digital input output section of a data acquisition interface provides bi-directional TTL level control and status ports that can be set and read by the computer. These can be used to control devices or to monitor switch or contact closures. Handshaking is sometimes provided to allow communication with peripheral devices.

Timing I/O

To perform multiple conversions at precisely-defined time intervals, data acquisition boards are equipped with counters and timers. The counter/timers are used to control both A/D and D/A data conversion. They work by counting an accurate fixed frequency oscillator provided by the interface or some external source. This clock frequency determines the granularity of the available settings. Higher frequencies offer finer granularity. Some boards provide counter/timers channels for the user. These can be extremely flexible and used in dozens of configurations.

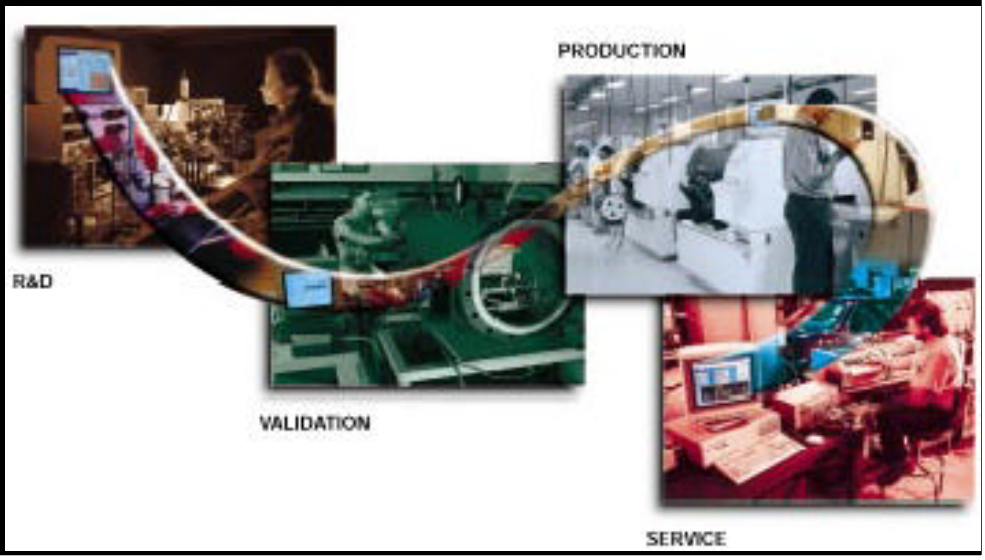
SOFTWARE

- ACQUIRE DATA AT SPECIFIED SAMPLING RATES
- ACQUIRE DATA IN THE BACKGROUND WHILE PROCESSING IN THE FOREGROUND (CONTINUOUS DATA ACQUISITION)
- USE PROGRAMMED I/O, INTERRUPTS, AND DMA TO TRANSFER DATA
- STREAM DATA TO AND FROM DISK
- PERFORM SEVERAL FUNCTIONS SIMULTANEOUSLY
- INTEGRATE MORE THAN ONE DAQ BOARD
- INTEGRATE SEAMLESSLY WITH SIGNAL CONDITIONING EQUIPMENT

DAQ hardware without software is of little use and DAQ hardware with poor software can be worse. The majority of DAQ applications use dedicated software. Most of the software directly programs the registers of the DAQ hardware, manages its operation and its integration with the computer resources, such as processor interrupts, DMA, and memory. The software hides the low-level, complicated details of hardware programming while preserving high performance, providing the user with an easy-to-understand interface. DAQ software must have the following functionality to:

- Acquire data at specified sampling rates
- Acquire data in the background while processing in the foreground known as continuous data acquisition
- Use programmed I/O, interrupts, and DMA to transfer data
- Stream data to and from disk
- Perform several functions simultaneously
- Integrate more than one DAQ board
- Integrate seamlessly with signal conditioning equipment

DAQ APPLICATIONS



The following is just a small sampling of applications that have been implemented using data acquisition solutions:-

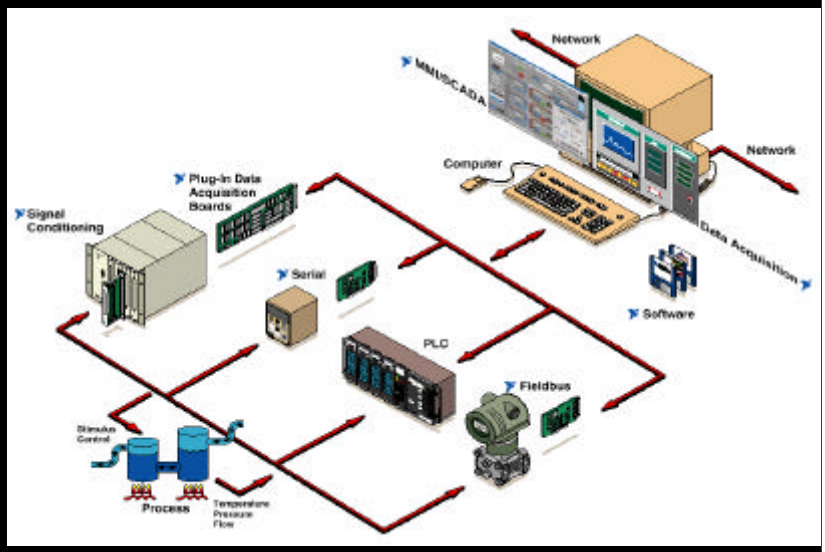
- **Noise, Music, Speech** for source identification, reduction overtones, decibels, dynamic range patters, voice recognition
- **Materials Science** for industrial coatings processing, semiconductors, radiation monitoring
- **Electrophysiology, Cardiovascular, Pulmonary** for EKG, EMG, EEG, blood flow & pressure, lung capacity, flow
- **Industrial Chemicals, Pharmaceuticals** for process control
- **Circuits analysis and data collection for** power supplies, resistors, capacitors
- **Electro-mechanical components** for switch closure, time, motors
- **Electronics, lab, repairs** for components testing
- **Geological oil exploration** for seismic studies, pipe lines
- **Materials properties** for stress, strain, fatigue
- **Mechanical** for structures, turbines, brakes, fuel injection, noise, vibration, pumps, valves, filters, compressors, springs, predictive maintenance
- **Teaching, lab skills** for math, science, engineering

DAQ APPLICATIONS

- NOISE, MUSIC, SPEECH
- MATERIALS SCIENCE
- ELECTROPHYSIOLOGY
- INDUSTRIAL CHEMICALS, PHARMACEUTICALS
- CIRCUITS ANALYSIS AND DATA COLLECTION
- ELECTRO-MECHANICAL COMPONENTS
- ELECTRONICS, LAB, REPAIRS
- GEOLOGICAL OIL EXPLORATION
- MATERIALS PROPERTIES
- MECHANICAL
- TEACHING, LAB SKILLS

INDUSTRIAL AUTOMATION

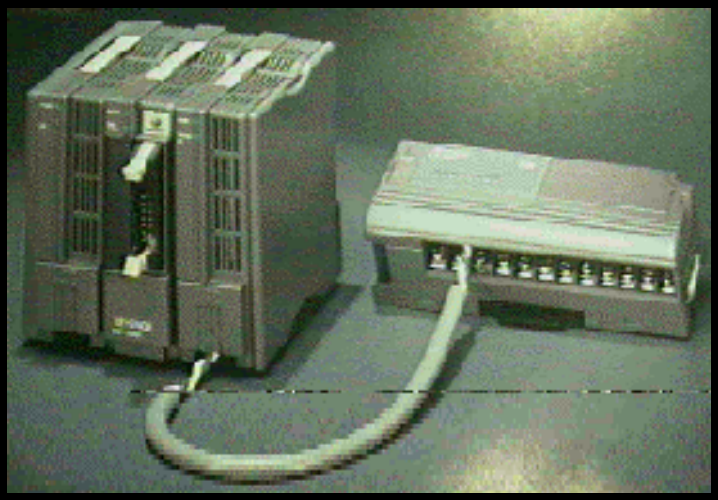
- **PLC**
- **GPIB**
- **DSP**



Industrial automation refers to the wide range of hardware and software products and protocols used to communicate between standard computer platforms (PC, Macintosh, or workstation) and devices used in industrial applications. Industrial automation requires sophisticated hardware and software to ensure robust, reliable, and sometimes real-time operation. Some of the commonly used data acquisition systems used for industrial automation are:-

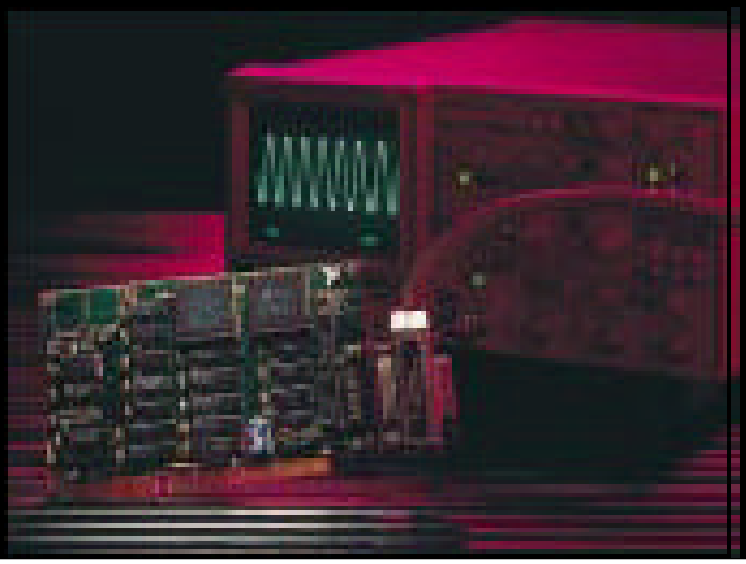
- Programmable logic controllers
- General purpose interface bus
- Digital signal processing

PROGRAMMABLE LOGIC CONTROLLERS



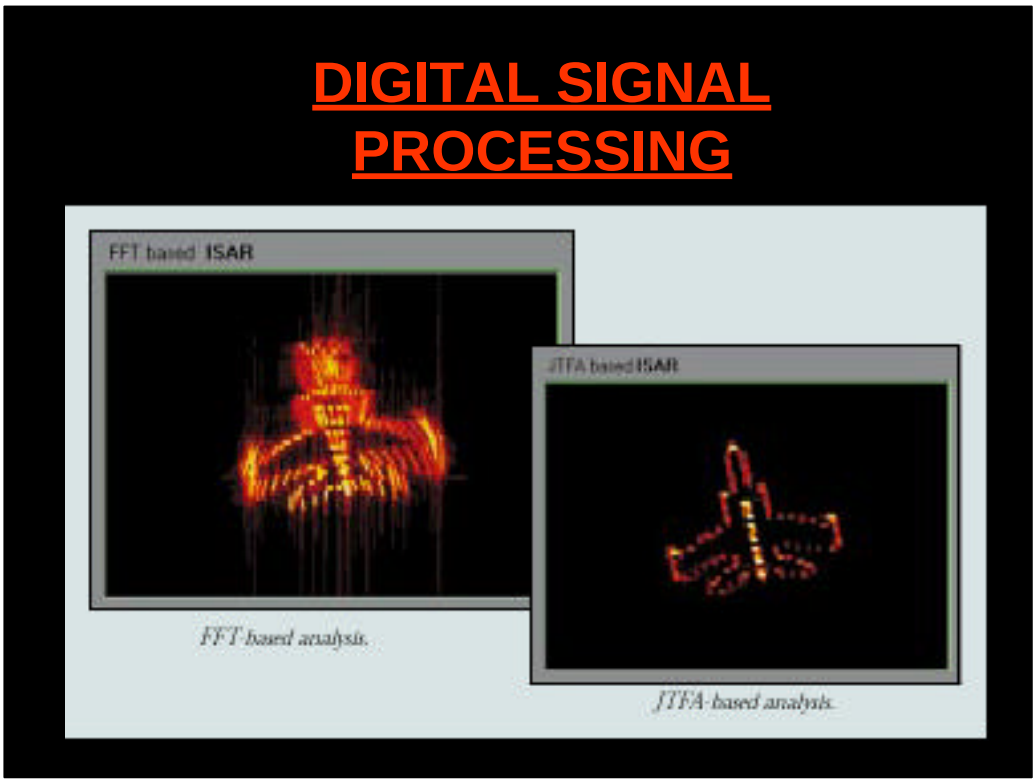
Programmable Logic Controller is a device that was invented to replace the necessary sequential relay circuits for machine control. The PLC works by looking at its inputs and depending upon their state, turning on/off its outputs. The user enters a program, usually via software, that gives the desired results. PLCs are used in many "real world" applications. If there is industry present, chances are good that there is a PLC present. If an industry is involved in machining, packaging, material handling, automated assembly etc it is probably using PLC’s. Almost any application that needs some type of electrical control has a need for a PLC.

GENERAL PURPOSE INTERFACE BUS



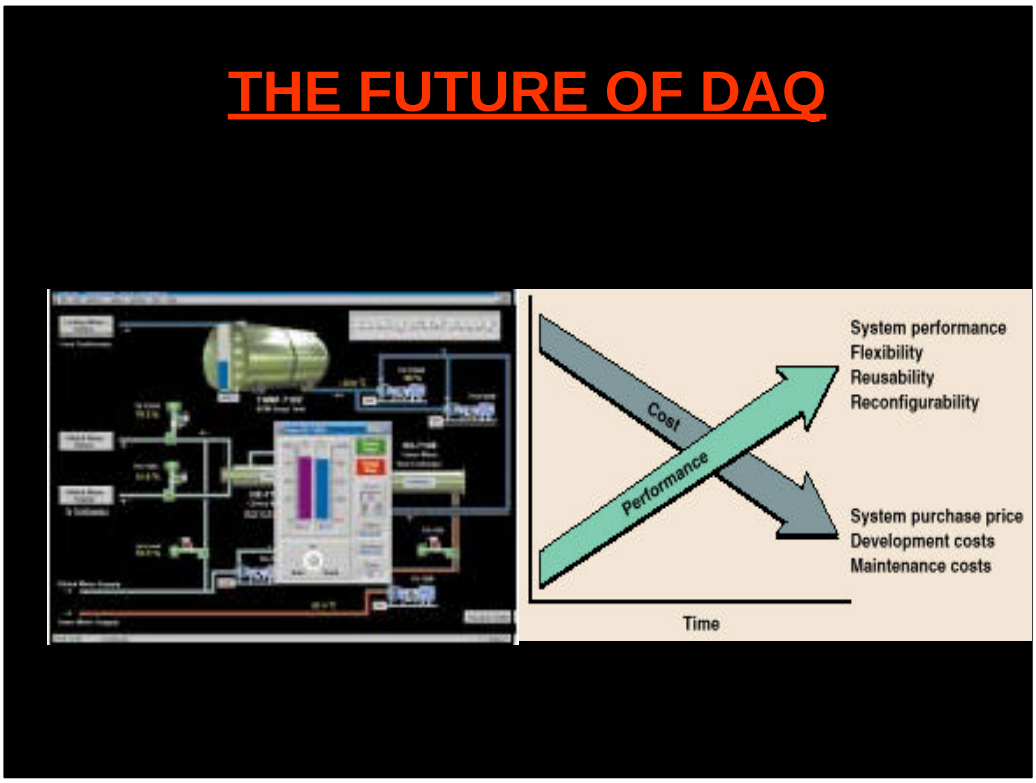
The GPIB was developed to connect and control programmable instruments, and to provide a standard interface for communication between instruments from different sources. Hewlett-Packard originally developed the interfacing technique, and called it HPIB. The interface quickly gained popularity in the computer industry. Because the interface was so versatile, the IEEE committee renamed it GPIB (General Purpose interface Bus).

Almost any instrument can be used with the IEEE-488 specification, because it says nothing about the function of the instrument itself, or about the form of the instrument's data. Instead the specification defines a separate component, the interface, that can be added to the instrument. All industrial measurement and control systems are usually automated using the GPIB bus.



A more appropriate definition for DSP as it applies toward the computer industry can be derived from the name *digital signal processing* itself. DSP is the *processing* of analog *signals* in the *digital* domain. Real-world signals, such as voltages, pressures, and temperatures, are converted to their digital equivalents at discrete time intervals for processing by the CPU of a digital computer. The result is an array of numerical values stored in memory, ready to be processed. DSP is useful in almost any application that requires the high-speed processing of a large amount of numerical data. The data can be anything from position and velocity information for a closed-loop control system, to two- dimensional video images, to digitized audio and vibration signals.

Common use of DSP in industrial applications is that of image processing and pattern recognition.



The future of DAQ lies in a world where all events are monitored and processed using Virtual Instruments. The traditional instrument is self-contained,with signal input/output capabilities and fixed user interface features such as knobs, switches, and other features. Inside the box, specialized circuitry, including A/D converters, signal conditioning, microprocessors, memory, and an internal bus convert real-world signals, analyze them, and present them to the user. The vendor defines all the instrument functionality which the user cannot change it. Virtual instruments leverage off the open architecture of industry-standard computers to provide the processing, memory, and display capabilities; off-the-shelf, inexpensive DAQ boards and GPIB and VXI interface boards plugged into an open, standardized bus provide the instrumentation “front end”capabilities. Because of the open architecture of PCs and workstations, the functionality of virtual instruments is user defined, and thus scalable and extensible.With the rapid development of high technology data acquisition and control systems, more and more real world events are being captured and processed using computers. The availability of off-the-shelf data acquisition equipment helps in automating most of the tasks through various control systems. The future of data acquisition lies in extremely fast data capturing and processing systems that would emulate a true real time control system.