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DEVELOPMENT OF A COMPUTERIZED CONTROL AND MONITORING SYSTEM FOR INDUSTRIAL APPLIANCE USING MICROCONTROLLER BASED DATA ACQUISITION SYSTEM.

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Abstract- *Control system is the synergistic combination of mechanical engineering, electronic engineering, control engineering, computer engineering to create useful product or system. This paper presents development of a computerized monitoring and control system which is designed specifically for monitoring humidity and temperature change and also controlling of different industrial operation in industries based on sensor reading. In this system together with the microcontroller technology can be used in a wide variety of applications in industry, including computer peripherals, business machines, motion control, and robotics, which are included in process control and monitoring purposes. This computer control system is divided into two subsystems, electrical subsystem and software subsystem. In electrical subsystem the main components are temperature sensor, humidity sensor, microcontroller and communication module. On other hand the software subsystem consists of only a graphical user interface (GUI) of the control system in computer. In industry there are some operation where maintaining of certain level of temperature and humidity is necessary. This control system gives a privilege by gathering information about temperature and humidity and displays it with real time data plotting on the GUI of control system. In order to control the operation of different machine used in industry from this control system, the user just need to give command using software from the computer to what to do. Thus the monitoring and controlling can easily be done.*

Keywords: Control system, Microcontroller, Graphical User Interface (GUI), Communication module, Temperature sensor, Humidity sensor.

1. INTRODUCTION

A Computer control system is a system which is designed for specific control functions within a larger system, often with real-time computing constraints. Computer control systems contain processing cores that are either microcontrollers or digital signal processors (DSP). The key characteristic, however, is being dedicated to handle a particular task. Since the Computer control system is dedicated to specific tasks, design engineers can optimize it to reduce the size and cost of the product and increase the reliability and performance.

Computer control systems are widespread in industrial, commercial and military applications. At present these control systems are using in scientific research, space research, robotics, industrial purpose and in many other important sectors. In industry for modern manufacturing process computer control systems are vastly being used.

These systems are also called as industrial control system. Computerized feedback control systems are used in many different industries today in order to achieve greater productivity in our modern industrial societies. Industries that presently employ such automatic systems include steel making, food processing, paper production, oil refining, chemical manufacturing, textile production, cement manufacturing, and others.

Industrial control system (ICS) is a general term that encompasses several types of control systems used in industrial production, including supervisory control and data acquisition (SCADA) systems, distributed control systems (DCS), and other smaller control system configurations such as skid-mounted programmable logic controllers (PLC) often found in the industrial sectors and critical infrastructures.

ICSs are typically used in industries such as electrical, water, oil, gas and others. Based on information received from remote stations, automated or operator-driven supervisory commands can be pushed to remote station control devices, which are often referred to as field devices. Field devices control local operations such as opening and closing valves and breakers, collecting data from sensor systems, and monitoring the local environment for alarm conditions.

2. LITERATURE REVIEW OF DIFFERENT CONTROL SYSTEMS

There are different types of control system which are presently used for many different purposes. Among them most are used for monitoring and controlling purpose with real time data acquisition system.

SCADA (supervisory control and data acquisition) is a type of industrial control system (ICS). Industrial control systems are computer controlled systems that monitor and control industrial processes that exist in the physical world. SCADA systems historically distinguish themselves from other ICS systems by being large scale processes that can include multiple sites, and large distances. These processes include industrial, infrastructure, and facility-based processes [1].

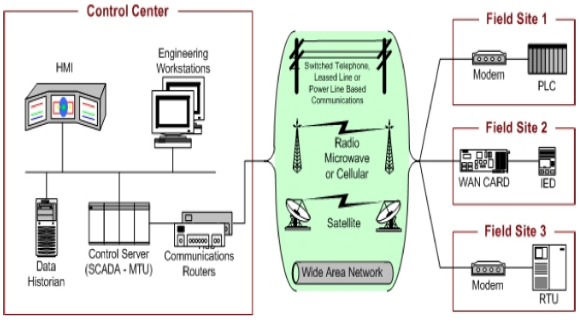

Figure.1: SCADA system general layout

A Programmable Logic Controller (PLC) or Programmable Controller is a digital computer used for automation of electromechanical processes such as control of machinery on factory assembly lines, amusement rides or light fixtures. PLCs are used in many industries and machines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a real time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result. PLCs are used in many industries and machines, such as packaging and semiconductor machines.

A distributed control system (DCS) refers to a control system usually of a manufacturing system process or any kind of dynamic system in which the controller elements are not central in location (like the brain) but are distributed throughout the system with each component sub-system controlled by one or more controllers. DCS (Distributed Control System) is a computerized control system used to control the production line in the industry. The entire system of controllers is connected by networks for communication and monitoring. DCS is a very broad term used in a variety of industries like car manufacturing industry, to monitor and control distributed equipment.

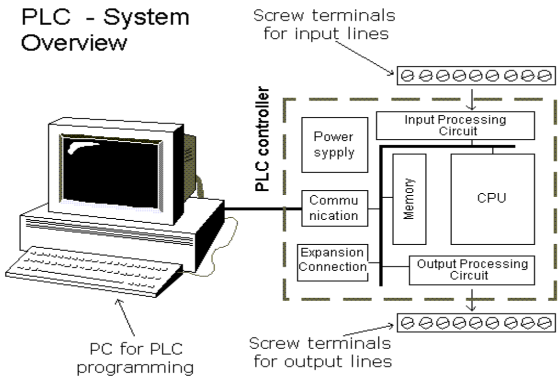

Figure.2: PLC system overview

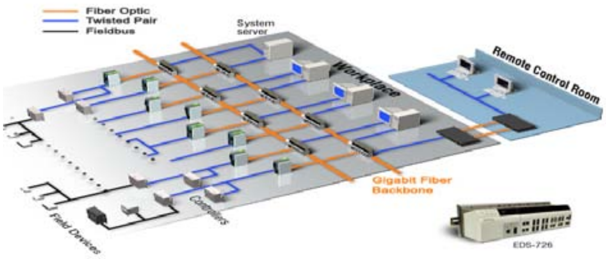

Figure.3: Distributed control system

3. DATA ACQUISITION PROCESS FOR THE CONTROL SYSTEM

There are several ways in which the data can be exchanged between instruments and a computer. Traditionally measurements are done on standalone instruments of various types' oscilloscope, multimeters, counters etc. However, the need to *record* the measurements and process the collected data for *visualization* has become increasingly important. Many instruments have a serial port which can exchange data to and from a computer or another instrument. Another way to measure signals and transfer the data into a computer is by using a Data Acquisition board. A typical commercial DAQ module allows input of analog signals through an ADC and output of analog signals through a DAQ. In addition a DAQ module may facilitate input and output of digital signals [2].

As digital electronic instruments have come to dominate many types of information systems including the acquisition of experimental data. The digital representation of an analog signal offers several advantages. A digital signal can be stored in volatile (RAM) or permanent (magnetic) memory; it can be reproduced error-free and can be imported into a computer for manipulation and analysis. There are two broad types of digital data acquisition systems commonly in use. The first consists of a computer, with a specialized plug-in board that performs analog-to-digital (A/D) and digital-to-analog (D/A) conversion. With the proper software to control the A/D board, the computer can act very much like a multi-channel oscilloscope, function generator, multimeter or other dedicated instrument. The second type of digital measurement system consists of a computer with an interface board that permits it to communicate with 'real' external digital instruments, such as digital oscilloscopes, function generators etc. The interface, known as GPIB (General-Purpose Interface Bus) or HPIB or IEEE 488, is a standard, similar in function to a serial (RS-232) interface that is commonly used to control printers and other computer peripherals. Both of these types of data acquisition systems are available in the ITLL. In this system, we have used serial (RS-232) Interface with Computer [3].

The components of data acquisition systems include:

1. Sensors that convert physical parameters to electrical signals.
2. Signal conditioning circuitry to convert sensor signals into a form that can be converted to digital values.
3. Analog-to-digital converters, which convert conditioned sensor signals to digital values.

4. PROJECT DESCRIPTION AND DESIGN TOOLS

The objective of this project is to design and develop a computerized control system which provides high quality features at a reduced cost compared with other computerized control system. Design of this control system is fundamental term of this project. Design is defined in such a way which gives a proper outline about this system or process. Here a design of this control system is outlined which explain by topics and diagram as given bellow:

Main Components: Voltage regulator (7805), Resistor, Capacitor, Crystal (20 MHz), Microcontroller (PIC-16F877A), MAX – 232, Breadboard, Diode, Adaptor, USB to serial Port (RS-232), Temperature sensor (LM-35), Humidity sensor (HSM-20G), Connecting wire. Among them important parts are described below:

Voltage regulator (7805): The 7805 is a voltage regulator. It looks like a transistor but it is actually an integrated circuit with 3 legs. It can take a higher, crappy DC voltage and turn it into a nice, smooth 5 volts DC. It needs to feed it at least 8 volts and no more than 30 volts to do this. It can handle around .5 to .75 amps, but it gets hot. Use a heat sink. Use it to power circuits than need to use or run off of 5 volts.

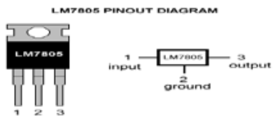

Figure.4: Voltage Regulator

Crystal Oscillator: A crystal oscillator is an electronic oscillator circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. This frequency is commonly used to keep track of time (as in quartz wristwatches), to provide a stable clock signal for digital integrated circuits, and to stabilize frequencies for radio transmitters and receivers. The most common type of piezoelectric resonator used is the quartz crystal, but other piezoelectric materials including poly crystalline ceramics are used in similar circuits [4].

Figure.5: Crystal

MAX 232: The MAX232 is an integrated circuit that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals. The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this case. The receivers reduce RS-232 inputs (which may be as high as ± 25 V), to standard 5 V TTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V. The later MAX232A is backwards compatible with the original MAX232 but may operate at higher baud rates and can use smaller external capacitors – 0.1 μF in place of the 1.0 μF capacitors used with the original device [5].

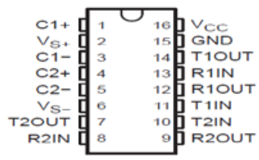

Figure.6: Pin Diagram of MAX232

USB to serial Port (RS-232): The USB to Serial RS-232 Adapter provides one RS-232 Serial (DB-9 male) connector via one standard USB port at a data transfer rate of up to 230Kbps. It can be instantly connected with modem, PDA, POS, or other serial devices on PC or Mac without the hassle of opening the computer case. This makes the USB interface transparent to serial peripherals, allowing them to easily interface with USB computers and eliminates the setup hassle found with additional serial port connections. This device also supports energy saving suspend and resume operations [6].

Figure.7: USB to serial Port (RS-232)

Temperature sensor(LM-35): The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in Celsius) [7].

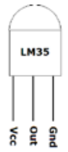

Figure.8: Temperature sensor LM-35

Humidity sensor (HSM 20G): The HSM 20G is an integrated circuit sensor that can be used to measure humidity with an electrical output. The module of HSM-20G is essential for those applications where the relative humidity can be converted to standard voltage output [8].

Figure.9: Humidity sensor (HSM 20G).

Working Principle: At first input voltage is supplied to the circuit. Then the output reading from the temperature sensor (LM 35) and humidity sensor (HSM 20G) are received by microcontroller as an input reading which is converted into digital form with the help of ADC channel in microcontroller. Then this Output reading is supplied to computer through MAX 232 module from microcontroller and finally showing the output in computer with the help of serial communication with the computer. For controlling the external devices from computer the instruction (signal) is sent to microcontroller via MAX 232.Then the external devices which are connected to the microcontroller can easily control by giving instruction from computer. This is the main working principle of this project. The block diagram and flow chart of the system are given below:

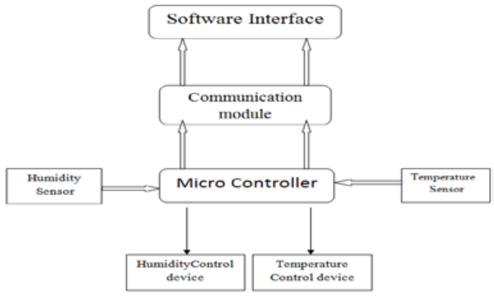

Figure.10: Block diagram of control system.

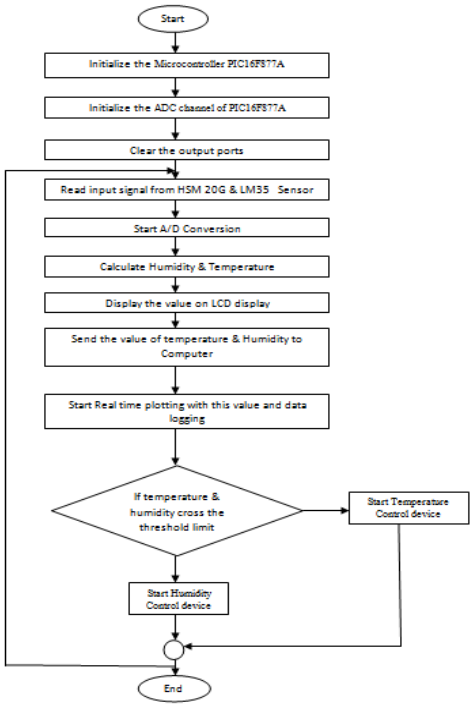

Figure.11: Flow Chart of control system.

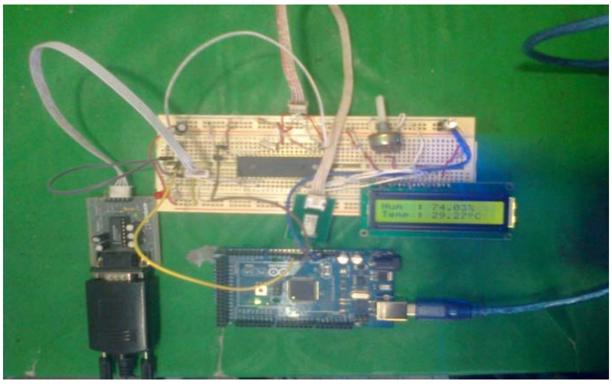

Figure.12: Snap of circuit.

5. INTERFACING AND DATA IMPORT

The hardware used in this project needs two different softwares. First one is driver software for serial port which links the hardware with the computer and the second one is the graph plotting software to receive desired data from the hardware and save the data within the software in data logger box. At first install ‘Serial Driver’ and this software is compatible for windows XP. If it is used in windows 7 change the compatibility to windows XP (Service Pack 2). After installing driver software connect the USB port of the serial cable to the computer and wait until the pc recognizes it. Then go to device manager option under the properties of ‘My Computer’ and find out the COM port in which device is connected. Here our device is connected through COM11. This COM port number can be different in different computer or this port number can be changed. Then open the graph plotting software.

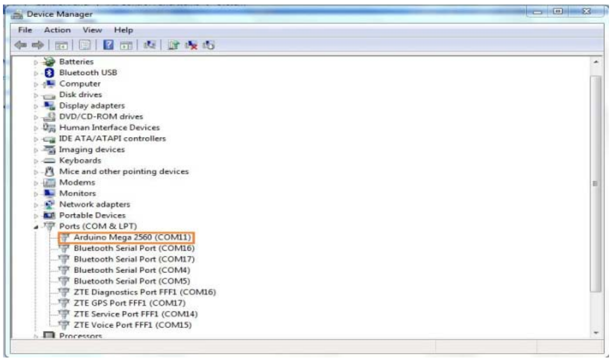

Figure.13: Snap of the COM port in device manager.

After opening the software we have to input the correct COM port number in the serial port text box. Then we need to press the connect button to connect the software interface with the hardware. After successful connection the software starts to receive the data of temperature and humidity. After receiving these data the software begins its data logging and plotting task. If we press the disconnect button the software stop receiving any type of data and also stop the data logging and plotting task. The Replot button used to start plotting again from beginning.

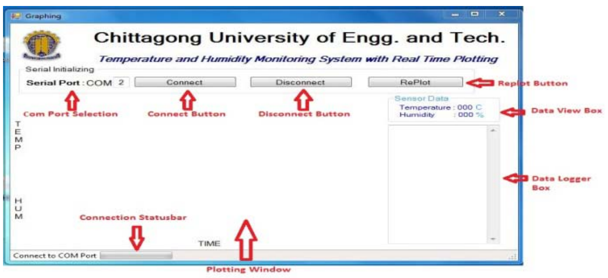

Figure.14: Snap of the software interface.

6. RESULT AND DISCUSSION

The results obtained by using the system are discussed in this section. The system has been experimentally tested for both real time monitoring and controlling purposes. The reading of temperature and humidity is continuously monitored with real time graph plotting and data logging which we can see in figure 15. The logged data of temperature and humidity can be saved within the software interface for further analysis.

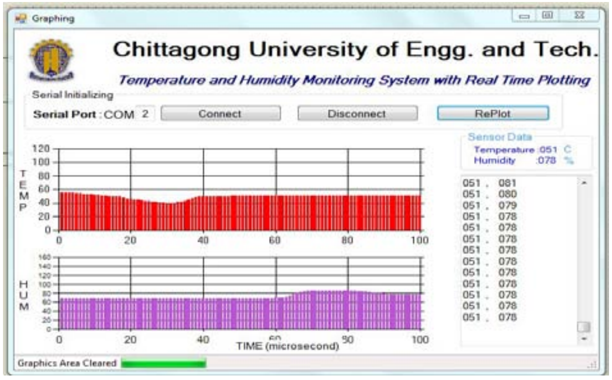

Figure.15: Snap of the software interface during operation.

In terms of controlling devices with the change of temperature and humidity the result is shown in tabular form below:

Table.1: Results of the system (for humidity change).

Humidity level (%RH)	Control instruction	Device to control
60	No instruction is sent	OFF
65	No instruction is sent	OFF
70	No instruction is sent	OFF
75	No instruction is sent	OFF
80	No instruction is sent	OFF
85	Control instruction is sent	ON

Table.2: Results of the system (for temperature change).

temperature level (Celsius)	Control instruction	Device to control
30	No instruction is sent	OFF
40	No instruction is sent	OFF
50	No instruction is sent	OFF
60	No instruction is sent	OFF
70	No instruction is sent	OFF
80	Control instruction is sent	ON

The above results confine that the monitoring and controlling devices is always within our desired level. If the value of temperature or humidity is near or more than the threshold limit then a control instruction is sent to control device through microcontroller to change its state. The system was tested for several times in different condition and the results were in good agreement with experimental values every time. So it can be said that the system is enough efficient to use for both monitoring and controlling.

7. CONCLUSION AND FUTURE WORK

The system has provided an economic and secure solution of monitoring and controlling for industrial operation. This system can be improved for a real time monitoring in complex system for both monitoring as well as controlling with large number of controlled devices. The system has been design and implemented in hardware using PIC microcontroller, communication module, temperature sensor and humidity sensor. The design was simulated and verified the correctness and working operation of the whole system. The system is very much cost effective as compared to the existing system.

In the future, this system can be easily modified for using in more and different application. By proper modification, the same setup of the system can be used to monitor and control parameters like pressure, force or flow rate of air or liquid by using only respective sensors. By integrating PLC devices and much more precise transducer sensor with the control system, this very same project is applicable to many high level precise works.

8. REFERENCES

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