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Integrated Automation & Control of Heating Ventilation and Air Conditioning System

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ABSTRACT

Integrated Automation & Control of Heating Ventilation and Air Conditioning is a centralized and interlinked network of hardware and software which controls and monitors the HVAC system. The function of integrated automation system is to control & monitor the temperature, humidity, air flow distribution and clean air of the HVAC system with minimum consumption of energy for cost savings. It is a concept, design and implementation to achieve an intelligent building management platform. This paper includes study and review in the area of automation and controls for the HVAC system. With the study and review of different strategies it has been observed that a supervisory control and data acquisition system with the use of Direct Digital Controller is widely used in buildings which are well versed with automatic programmable sequence, full manual operation option, data storage, display fault conditions and system monitoring. The application program is configured in a hierarchical manner that integrates the system using Internet protocols and open standards like XML, BACNET, LONWORKS and MODBUS..

Keywords

Heating Ventilation and Air conditioning, Direct Digital Controller, BACNET, LONWORKS, MODBUS.

INTRODUCTION

Heating Ventilation and Air Conditioning system is used to provide the conditioned air for a comfortable and safe environment. Conditioned air means that air is clean and odor-free and the temperature, humidity, and movement of the air are within certain specified ranges as per the requirement of the building. The system is used in medium to large buildings such as skyscrapers, aquariums and pharmaceutical industries where safe and healthy conditions are regulated. The aim of HVAC system is also to provide an environment suitable for the process. The process may be manufacturing with special requirement to ensure a quality product or it may be a laboratory, hospital or a pharmaceutical company where it requires precise temperature and humidity control along with maintaining of required room pressures and filtration. The system should be energy efficient and safe. HVAC systems are among the largest energy consumers in buildings. Energy costs through the life cycle represents the highest part of the overall operating costs of HVAC system. It is important to make th esystem energy efficient. Hence a control system is needed for the regulation of HVAC system. A sensing device is used to compare the actual state with a targeted state so as to take necessary action. A control system manages commands, directs and regulates the behavior of other devices or systems. The control system make the system stable and energy effiecient.

Parameters which are needed to be controlled in HVAC system

- Temperature & Humidity

ASHRAE Standard 55[2] offers guidelines and the chart below illustrates thermal comfort ranges for summer and winter. The table below summarizes the temperature and humidity range for human comfort.

Temperature / Humidity Ranges for Human Comfort		
		AcceptableOperating Temperatures
Conditions	Relative Humidity	°C
Summer (light clothing)	If 30%, then If 60%, then	24.5 to 28 23 to 25.5
Winter (warm clothing)	If 30%, then If 60%, then	20.5 to 25.5 20 to 24

- Ventilation

ASHRAE Standard 62-1999:
"Ventilation for Acceptable Indoor Air Quality"
recommends minimum ventilation rates per person in the occupied spaces. The recommended value of outside air is typically 20 CFM for each occupant.

- Pressure

The stable positive pressure of .01-.05" is recommended. Pressure comes in to play in buildings where air quality is strictly watched like hospitals. The rooms and buildings typically have a slightly positive pressure to reduce outside air infiltration.

- Special Control Requirements

The special requirements pertain to the interlocking with fire protection systems, smoke removal systems, clean air systems, hazardous or noxious effluent control etc.

History of Controls

The bimetallic strip was the first device used to regulate the space heating system. It controlled the boiler output by opening and closing the boiler door or the combustion air damper to control the rate of combustion. These devices were known as regulators. Dr. Andrew Ure was the first person to call his regulator as a thermostat which is used to control temperatures. The early control devices were generally electric, their function was to make or break an electric circuit that turned on a fan or pump, open a valve or damper. The need for inexpensive modulating controls lead to the development of pneumatic controls that used compressed air as the control power rather than electricity. With the invention of electron tubes analog electronic controls were developed. Finally with the emergence of microprocessors digital controls were developed which gave a precise control system and made HVAC control system effective. The HVAC control system has four basic elements: sensor, controller, controlled device and source of energy needed to power the control system which uses either an electric or pneumatic power supply.

Types of Control

- Open Loop Control (It is with no feedback i.e. there is no way to monitor whether the control system is working effectively or not. Open loop control is also called feed forward control) Signals flow from the input, through the system and produce an output
- Closed Loop Control (Closed loop control is also called feedback control)

HVAC control system

HVAC control systems are typically closed loops. The desired value or set point is adjusted at the knob on the front of the thermostat. The temperature sensor measures the actual value and sends a signal back along the feedback path to the comparison device. The comparison device compares the value of temperature at the sensor to that of the desired value or set point on the controller. The difference between the desired value and the measured value is known as the error signal. The error signal is fed into the controller as a low voltage signal (e.g. 10 volts) to the actuator. The controlled device, which is an actuator on 2-port valve reacts to the impulse received from the controller and varies the flow of the hot or cold water. This in turn changes the condition of the space or process to the desired value.

The HVAC control system is typically distributed across following areas

- The HVAC equipment and their controls located in the main mechanical room. Equipment includes chillers, boiler, hot water generator, heat exchangers, pumps etc.
- The Air Handling Units (AHUs) may heat, cool, humidify, dehumidify, ventilate, or filter the air and then distribute that air to a section of the building.
- The individual room controls includes fan coil units, variable air volume systems, terminal reheat, unit ventilators, exhausters, zone temperature/ humidistat devices etc.

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An Integrated Automation and controlled HVAC system

It uses hardware and software for improved performance and energy efficient system. It constitutes of a Graphical user Interface in which a software application reside on a network device or PC that provides graphical representation of the HVAC system or any other system like Fire Alarm system, Public Address system, security system, Electrical system etc . All these systems can be integrated under one platform and control and monitoring could be made. The software is capable of acting as a gateway between systems conveying messages, for example, from IP or Modbus devices to LON devices and vice versa. It can collect trends from defined points, collect and forward alarms from the systems and enable efficient management of user rights. The software is capable of forwarding alarms to mobile phones using SMS, local alarm printers or to Service Center. It shall be possible to browse the alarm history for reporting and statistical purposes. Next the integrated system has the control level which consists of distributed network of smart controllers, which communicate to each other using a commonly known field bus. It utilize standard TCP/IP protocol for connectivity to the GUI. The controllers shall include all the intelligence of the system. All mechanical and electrical systems can be monitored and controlled by smart control nodes connected to Local Operating Network (LON).

An Integrated Automation system constitutes an Intelligent building system for integration of various devices under single platform. It is configured in a hierarchical manner that integrates the system using Internet protocols and open standards like XML, BACnet, Lon and Modbus.The Integrated System Architecture consists of four levels:

1.Service Level

It allow the systems to be connected without additional software to one or several Service Center(s), for providing centralized remote monitoring, alarm and fault detection.

2.Management Level

It provides a uniform view to all systems through the open Building Operating System platform. The system offers Alarms Historical trending Logs and reporting User profile and role management

3.Control Level

The Control Level shall consist of a distributed network of smart controllers, which communicate to each other using a commonly known field bus.

4.Field Level

The Field Level shall consist of industry standard sensors and actuators, industry standard card readers and IP cameras.

Conclusion

The Integrated Automation Control is the best strategy wihich enables Comprehensive monitoring and control systems and improved energy efficiency. Among the various Controllers Direct digital Controllers are more suitable for an integrated automation which has PID controller. The Use of intelligent management system is having a large future scope in the commercial as well as industrial application. This control strategy is successfully implemented in many pharmaceutical industries and manufacturing firms. In manufacturing process the use of PLC controller are more effective than the DDC controller due to their quick response whereas the DDC controllers are more suitable for an HVAC system. This control strategy is widely used with Green building concept where energy savings and reduction in cost is gained.

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