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Building Management System of High-Rise Buildings with Execution

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Abstract – The fundamental module for regulating and automating tasks is a system for building management (BMS), which is presented in this study. In addition to security, the major area of this BMS concentrates on switching and managing the HVAC Control. Systems for providing building services today include technical, electrical, and control elements. In the modern world, different building subsystems have generally been run independently, each with a distinct information technology (IT) framework. These conventional systems suffer from additional losses, such as wasted time and energy. To lower operating costs for energy in the building's energy management and operation, this research designs and implements a Building Management System (BMS) using the Web of Things (IoT) that manages and tracks three subsystems: the environment, ventilated, and temperature systems. Building systems need regular maintenance or assistance to remain operating at their best. They also need to be modified and expanded to accommodate new construction and renovations. guarantees that the complete BMS and Accessibility Control Systems are regularly maintained so that the plant maintains control at optimal levels and the system for access control runs smoothly.

Keywords – Building Management System, Internet of Things, Information Technology, Energy Management System, Direct Digital Control

I. INTRODUCTION

Architecture is not only a craft but also a way of thinking that prioritizes practicality in service to its intended function. Because of the significant social and environmental impacts associated with their work, architects play a pivotal role in bringing about the physical, social, & aesthetic demands of society. It has been widely held since antiquity that architects intentionally or unintentionally embed hidden messages into their works. Because of the rapid pace of technological progress, our planet is morphing into an artificial, industrialized community [1]. The pressure for metropolitan areas to expand and become denser has only been rising. People are migrating from rural areas to urban centers all over the world. As a result, land is becoming more scarce and costly in urban areas, forcing developers and builders to go upward. The sky and the answers to the difficulties they cause are both creations of our time. There has been a lot of collaborative effort to form the public sphere. Still, the city of the 20th century was mostly a reflective product of individuals and organizations competing to maximize their perceived advantages [2].

MEP (Mechanical, Electrical, and Plumbing) services like Fire Apprehension Systems, Fire Fortification Systems (Fire Thrusts, Sprinkler Systems, Foam Systems, FM-200, Deluge Systems, Pre-action Systems, Clean Agent Systems, LPG (liquefied Natural gas Gas), LNG (liquefied Natural Gas), etc., high-rise structures are those with a height greater than 46 meters. Differentiating from low-rise and medium-rise buildings, a high-rise has a small footprint on the ground but a huge height above it, and its extraordinarily tall façade needs specialist engineering systems [3]. (Scott, 1998). Eventually, a more accurate one was developed: "A tall rise is any structure whereby the height can have an important effect on evacuation." High-rise residential buildings have grown increasingly commonplace in many cities, displacing extensive regions of vernacular dwellings as a natural consequence of the increasing population and rapid pace of urbanization. If you consider the whole timeline of human habitation, the housing procedure used to construct these structures is revolutionary. Unlike in the past, architects and developers now have a monopoly on the construction of high-rise residential structures, which house vast numbers of people. Business activity was the primary motivator for new developments in early high-rise construction. Business considerations were integral to the design process [4].

The main considerations for spending and benefiting from Cost-effectiveness, efficiency, scale, and timeliness were all highly valued by the workers who erected these structures (Huxtable, A., and Ada, L., 1992). While increasing the number of tall buildings in an area can alleviate issues with population density and the scarcity of development land, these structures are often more about displaying authority and prestige than being functionally efficient. The cultural and political makeup of a city is influenced by its physical appearance, as well as by a historic rush to the sky & the marking of the city that resulted in a conflict between modernity and conventionality (Sorkin, M., 2001) [5-9]. As a sign of rapid urbanization, high-rise structures have mostly supplanted great mosque minarets. The fall of the World Trade Center's 110-story twin buildings on September 11, 2001, delivered a terrible message to the world: a new era is emerging for High-Rise Buildings. Since then, there has been a heated debate in the realms of engineering code writing, fire prevention, and political circles regarding the safety of tall structures and the proper role of government authorities [10].

II. Literature Review

Building management systems can now control multiple sectors, such as industry, communication, and automate a building's functions, including regulating power intake, security, and HVAC processes. Smart building technology has revolutionized BMS, resulting in unprecedented advancements. Microprocessor-based BMS centralizes building services management, resulting in time and cost savings while maintaining safety and comfort in the workplace.

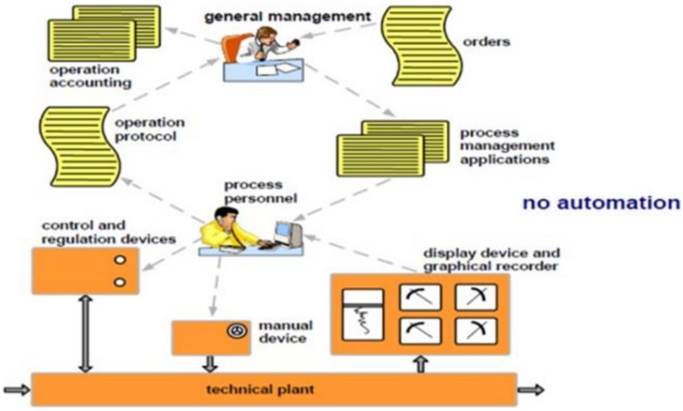


Fig. 1 Building Systems without BMS

The Building Management System (BMS) is responsible for monitoring and controlling a building's operations such as HVAC, lighting, electrical, protection, and security. It is a computer system that includes both hardware and software and is structured hierarchically using protocols like C-Bus or Profibus.

Data has become the primary driver of change in our culture, and Microsoft (MS) is the primary hub for collecting and using data. BMS is developed to improve energy efficiency, as buildings account for 40% of total energy usage. Modern BMS systems combine historical trend analysis with continuous monitoring to maximize component performance [13].

Building information modelling (BIM) enables the adoption of BMS solutions during the project's design stages, which improves BMS integration and lowers operational costs [15-17]. In addition to reducing expenses, BMS and related technologies are also increasing returns. Advanced BMS-enabled buildings have an edge in the market because of their increased safety, security, and adaptability. Building owners who invest in smart technology are more likely to get high-quality tenants willing to pay

premium rents. As building management systems (BMS) and the Internet of Things (IoT) advance, we may expect to see higher cost reductions and additional functionalities, resulting in unparalleled value from the structure itself. Building management systems (BMS) have evolved into the lifeblood and beating core of the linked, data-rich buildings of the future. Byte-Management-System, or BMS, is an energy-saving technology that takes into account the unique requirements of each building by regulating the HVAC and other mechanical systems. Panels attached to the gadgets put outside the buildings allow them to be turned on and off in response to a variety of commands [18].
The BMS cannot function without the information provided by devices such as sensors, which is then processed by a controller to instruct the system to take a specified action; for instance, [19], the power to the establish may be turned off or on, and the temperature of the facility can be altered to provide reassurance for those with a participant that it has the upon signatures beyond the building. Building management systems (BMS) have been around for more than 30 years [20-21]. However, their usage has skyrocketed in the past five years as the price of microprocessors has dropped and software has gotten more user-friendly. One-Zone Controlled Variable Air Vol (VAV) Systems.

- Controlling CO2 levels in three distinct areas (Air Quality).
- Adjust the temperature of the air supplied by the air handler.
- Control the airflow and pressure using air handling equipment.
- Sequencing of the Main Plant's Chillers and Boilers.
- Seven-regulating exhaust fans in restrooms, garages, kitchens, and other areas.
- Control of the Building after Hours, Number.
- Keeping an eye on and regulating the temperature.

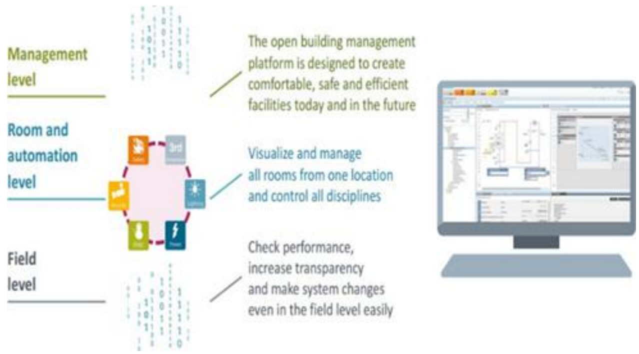


Fig. 3 BMS Levels

III. Solution Toward Building Management System

The direct digital controller is a key component of any building automation system. It is responsible for monitoring and controlling various mechanical and electrical systems in a building, such as HVAC, lighting, and security. The DDC works by receiving input from sensors and other devices, analysing the data, and making adjustments to the systems as needed. This helps ensure that the building operates efficiently, safely, and comfortably for occupants. With the right programming and setup, a DDC can be an invaluable tool for building management and maintenance.

A. *System Requirements*

The HVAC control system must use electronic Direct Digit Control (DDC) that is separate from the rest of the system. The system shall be of modular design consisting of field equipment (sensors and control devices) and panel-mounted controllers. Each controller shall be of the standalone type. When two AHUS are located in one mechanical room, one single controller can be provided. Each component and subsystem shall be installed as specified herein and as shown on the Drawings, with all equipment and software provided as required to satisfy the performance requirements specified herein. All controls shall be "BACnet" compatible for future connection to a BMS system.

B. *Controller*

Each field panel should have a microprocessor-based controller with storage, software, I/O, and power. The controller must perform calculations, process commands, and operate independently. It should receive and transfer data from field sensors. If labelled "DCC," it must have "DDC" software. Proportional, integral, and/or derivative control algorithms should be integrated. Other control modes should be implemented. The software must be field-programmable and enable arbitrary functions and algorithms. The purpose is to enable a controlled rest and an optimized start and stop. The keypad should enable the programming of all parameters. The following functions must be built into each controller:

The controller requires high-voltage surge protection, power conditioning, and fuses, and has terminals to verify incoming data. It features power failure recovery, non-volatile memory, and energy management applications including timing start/stop, night setback, and supply air temperature reset. A keyboard and screen are necessary for its operation, and it can activate/deactivate machinery, show control loop set points, and establish alarm times.

The energy management software includes Air Handling Unit scheduling, Optimal "Start" and "Stop" Programs, and supply air temperature reset. Labels must be printed in English and Urdu for supplementary items signs and plaques.

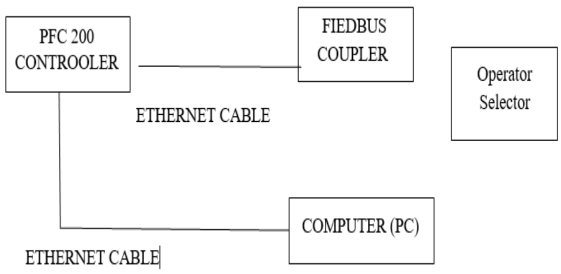
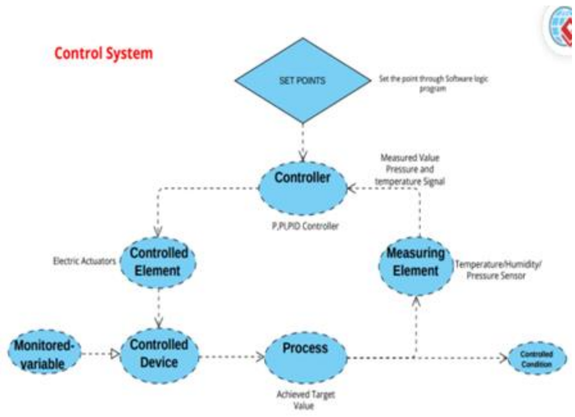


Fig. 4 Network Layout

C. *Equipment*

- Air Filter Gauges:
- Control Devices
- Thermostats:
- Duct Smoke Detector:
- Differential Pressure Switch (Air Distribution):
- Duct Temperature Sensor:
- Flow Switches (Hydronic)

IV. Method and Materials



.Fig..5 The Control System of BMS

The DDC will be programmed through specific software and the programmed language should be text-based or picture-based. But in this research, we used logic-programmed language to set our points. The above figure explains the control system for our BMS.

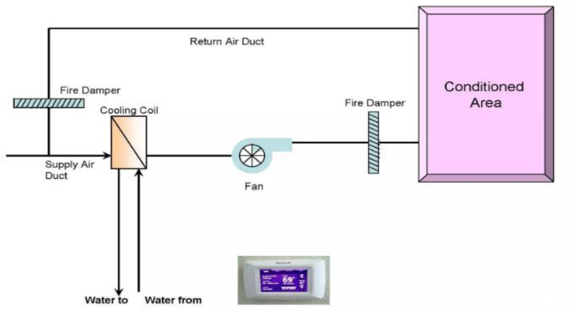


Fig. 6 AHU System without BMS Sensor

In the above AHU, there is no BMS sensor, and operates manually, the temperature of the room adjusts manually there is no control

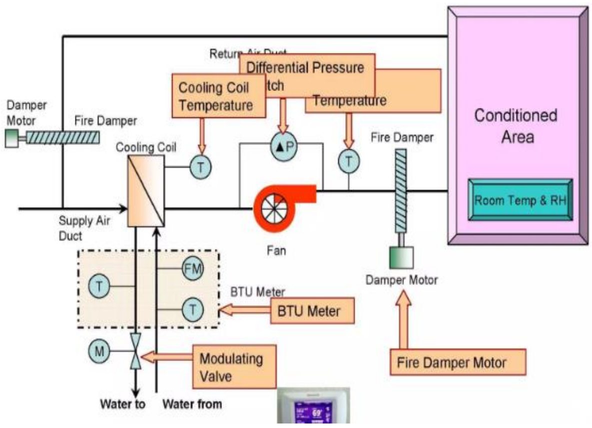


Fig. 7 AHU System with BMS Sensor

We have integrated the AHU system with the BMS sensor. This integration is a crucial aspect of the building's HVAC system, and I am working diligently to ensure that everything is running smoothly. By monitoring the air quality, temperature, and humidity levels, the BMS sensor assists the AHU system in making necessary adjustments. This results in a comfortable and healthy environment for the building's occupants, all while saving energy and reducing costs. In this research system, we used DDC which performed on AI, DI DO, and AO are the controlling inputs and outputs. In the above figure, the sensor will monitor the temperature, humidity, modulating valve, and differential pressure of the air all these field devices need a proper connection to DDC.

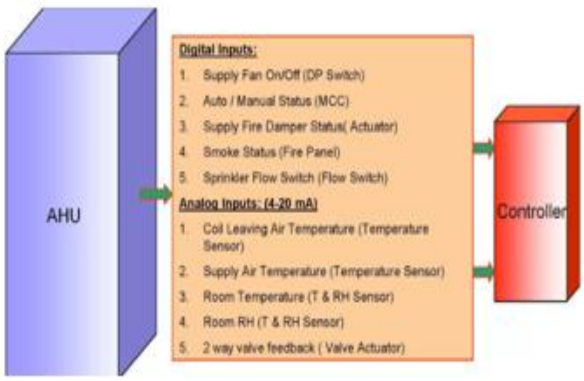


Fig. 8 Inputs to the Controller

The sensor will give input in the form of digital inputs or analog inputs. The above figure shows the inputs to the controller.

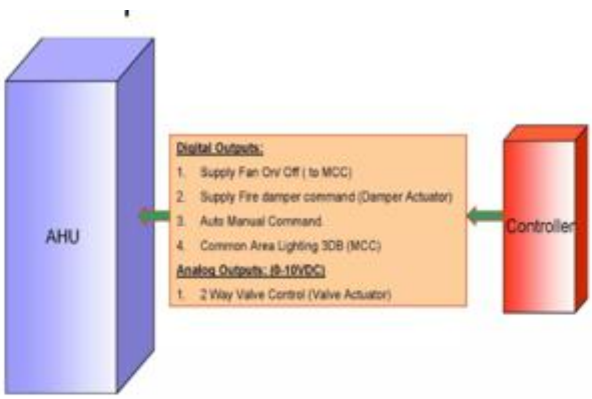


Fig. 9 Outputs from the Controller

In response, the controller works according to the program and generates the following outputs which will be Digital outputs and Analog outputs.

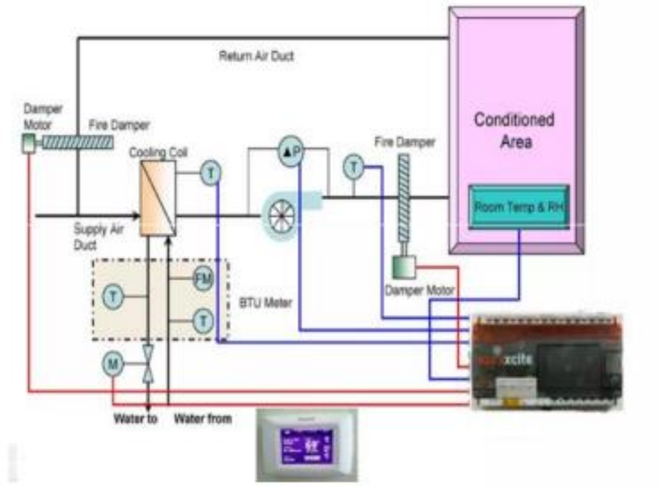


Fig. 10 AHU System with DDC Connection

In the above Fig 10 AHU system is connected to DDC which will control the room temperature according to human requirements. First the system need a proper input and output summary of DI AI, DO, and AO. The following table shows the Input and output control summary for DDC.

A. *AHU BMS System*

- System 1: Temperature sensor that supplies air temperature to the controller. DDC generates a DO signal to enable the system valve.
- System 2: Sensing supply air pressure and generating analog input signal. DDC generates a DO signal to adjust pressure.
- System 3: Sensing returns air temperature and generates an analog signal. DDC generates a digital output signal to enable the system.

B. *DX Air Conditioning Unit*

- System 5: Senses room temperature. The signal is an analog input to DDC. DDC automatically enables the system.
- System 6: Senses room humidity. Generates analog input signal to DDC. DDC automatically enables the system.
- System 7: Sensing supply fan differential pressure generates analog input signal. DDC generates a digital output signal to enable the system.

C. *Duct heater*

- System 9: Senses room temperature. Sends analog input signal to DDC. DDC generates a digital output signal.
- System 10: Starts responding according to human requirements.

D. *Exhaust Fan*

- System 12: Starts/stops the exhaust fan. DDC generates a digital output signal to start the system.
- System 13: Checks the status of the exhaust fan ON/OFF and generates an analog input signal to DDC. The main operator will monitor it on the main computer.

E. *Fire Alarm System*

- Sends digital input signal to DDC device in case of fire. DDC device will automatically enable the sprinkler system and stop all concerned systems**.**

V. IMPLEMENTATION AND EXCUSTION

To implement our research work we have designed an execution plan which shows the complete structure for BMS. As in the execution plan, we can operate all HVAC components from the operation Station the main computer and the controller can communicate through BACnet protocol. The main computer is connected to the BACnet Switch. The BACnet protocol is a widely adopted standard for building automation and control networks. It allows for the seamless integration of various building systems, such as HVAC, lighting, and security, into a single, unified system. With BACnet, building owners and operators can easily monitor and control all aspects of their building's performance, from energy consumption to occupant comfort. This protocol is highly flexible and scalable, making it suitable for buildings of all sizes and complexities. Overall, BACnet is an essential tool for modern building management and automation.

I must acquire a top-notch building management system for my HVAC system. The system must be highly efficient, dependable, and user-friendly. I require a single interface that will enable me to monitor and regulate the temperature and air quality in my building, as well as track energy usage and make adjustments to save money. Additionally, the system should be capable of alerting me to any issues or malfunctions, so that I can promptly address them. In summary, I'm seeking a system that will enable me to maintain a comfortable and healthy environment for my occupants, while simultaneously maximizing energy efficiency.

The DDC panel is connected to the BACnet Switch. The BACnet Switch provides multiple connections. We can connect multiple DDC panels. In the below figure, we can design the control system for HVAC. Different companies provide software through which we can program our DDC panel. all HVAC system is controlled from the operation room.

Below Figure 12 is the control diagram for HVAC which explains the Case study, which is discussed above.

In this research, we used the Schneider Electric DDC Panel because their performance is better than other companies.

After conducting extensive research on Schneider Electric DDC, it is clear that this solution is an excellent option for building automation. The advanced technology enables remote monitoring and control of a building's HVAC, lighting, and other systems, which ultimately leads to increased energy efficiency and significant cost savings. Additionally, the user-friendly interface allows building operators to easily make adjustments and track performance. In conclusion, it's safe to say that Schneider Electric DDC is a valuable investment for any building owner or manager who wants to enhance their facility's operations.

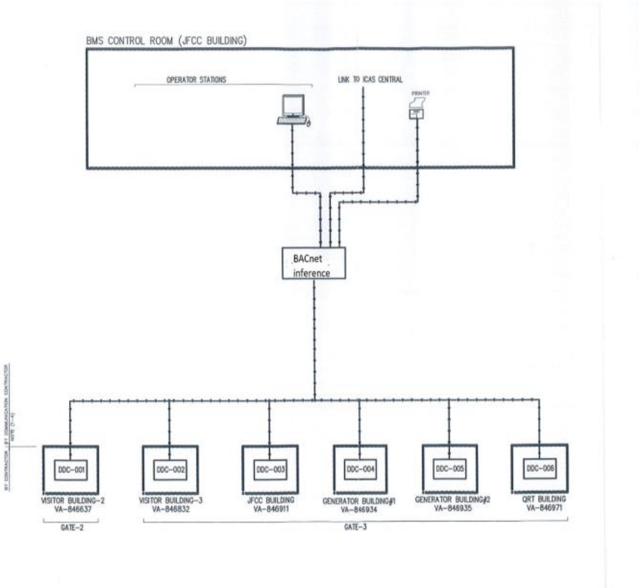


Fig. 11 shows the BMS network layout

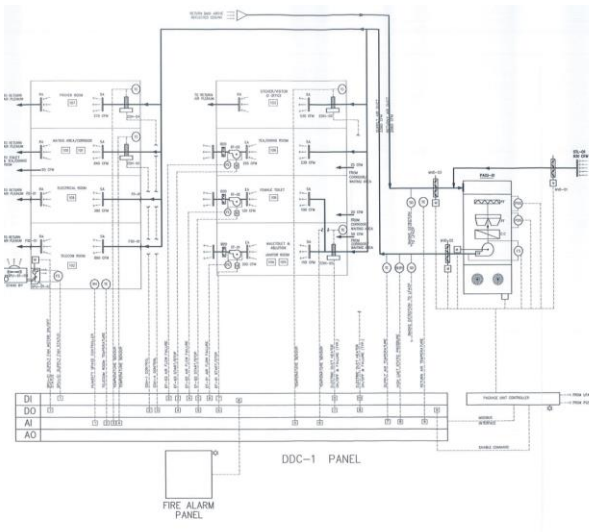


Fig. 12 HVAC Airflow and Control Design

Figure 11 & 12 is the detailed diagram for the execution of the BMS for HVAC for high-rise buildings. The DDC panel is programmed through Schneider Electric software.

VI. Result and Discussion

Upon successful execution of the BMS for HVAC,

Fig. 13 AHU Supply and Return Status

The user interfaces for operating and monitoring the machine are set to standard. The HMI above presents the current status of AHU supply and return air. It is important to note that AHU 05's supply air status is ON while its return-B status is OFF. With this information, you have full control over the AHU supply and return air.

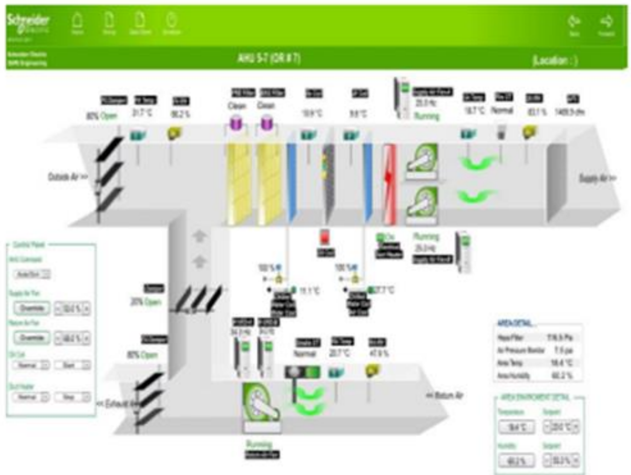


Fig. 14 AHU monitoring and Visualization

Advanced user interfaces for operating and monitoring machines are now the norm. The design of an HMI-based system is a critical factor that greatly influences the decision to purchase an entire automation line. With Schneider Electric software, the design process is simplified through the use of drag-and-drop functionality. In addition, the integrated visualization editor provides access to IEC program variables and allows for a closed simulation of the HMI and PLC programs on the engineering PC. The Unicode character set is utilized to ensure language independence and adherence to current standards, such as HTML 5 or CSS. This research showcases two systems, including the ventilation and temperature systems, as depicted in the figure.

Fig. 15 Area detail and Setpoints

Through the computer-based interface shown above, we can set the temperature and humidity levels in the control room. The AHU system must operate according to these set points. Currently, we have set the temperature to 22.0 Celsius degrees and the humidity level to 55.0%. We are closely monitoring the air pressure as well.

In this research, we have also controlled our HVAC System through a computer-based interface We can effortlessly manage our AHU supply air fan, return air fan, DX coil, and duct heater by simply turning the system on and off from the control room.

Based on my thorough comparison of BMS and non-BMS systems, I can confidently assert that BMS is a game-changer. Its exceptional efficiency and accuracy leave non-BMS systems in the dust, which are prone to costly errors and inconsistencies. BMS offers a streamlined approach that not only saves time, and energy but also saves money. I highly recommend using BMS for any organization looking to improve their operations.

VII. Conclusion

The primary objective of this design is to propose a solution for a High-rise building that effectively controls and monitors three crucial subsystems: the lighting system, the ventilation system, and the temperature system. The BMS operates solely based on input in the form of information gathered by sensors and other devices. Once the information is collected, it can be processed with the help of a controller, which will then instruct the system to carry out specific tasks. With this BMS, the operation of the plant can be switched on and off, and the plant can be set to a specific temperature to measure temperature by the sensor and operate the ventilation and lighting system accordingly.

The design requires the installation of a controlling and monitoring device during the construction phase of a building. Three subsystems are studied in this design: ventilation, lighting, and the temperature system. It is being constructed to provide maximum comfort and ease to people with minimal energy utilization. Intrusions can be easily monitored with the help of a control system or a manual switch. The results achieved are remarkable, as the system can be easily controlled and monitored locally or remotely, leading to a significant reduction in running costs for the building by saving energy.

Acknowledgment

I appreciate the guidance and assistance that my MS supervisor, Dr. SHERAZ KHAN, continues to provide. Without their amazing support and encouragement, I would never have been able to do my research.

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