Palestine Polytechnic University

College of Engineering

Controlling and Monitoring for Modeling of HVAC System using BMS

By

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Submitted to the College of Engineering in partial fulfillment of the requirements for the Bachelor degree in Industrial Automation Engineering

Hebron, May 2017

Palestine Polytechnic University

College of Engineering

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Abstract

In this project we design air condition system which simulates the heating ventilation and air conditioning (HVAC) System, and we have been taken in consideration the cost of build this system the lowest possible costs.

During this project we will build a control system working to control of temperature, pressure, and ventilation and monitoring the system by using BMS system, the control system depends on the sensors and actuator that we choose.

We will to build control system for temperature in the Room, by using mathematical operation on the BMS system, when the temperature in the room is less than the set value and the temperature of air in outdoor less than the set value the heater is on by using Pulse Width Modulation (PWM).

الملخص

في هذا المشروع تم العمل على تصميم نظام تكييف وتبريد يحاكي بشكل عام نظام التدفئة والتهوية والتبريد الهوائي "HVAC System"ولكن ضمن الإمكانيات المتاحة وتم الأخذ بعين الإعتبار أن يتم بناء النظام الميكانيكي بأقل تكاليف ممكنة لذلك لجأنا إلى قطع متوفرة.

وخلال هذا المشروع سيتم العمل على بناء نظام تحكم يعمل على التحكم بـ درجة الحرارة والتهوية وضغط ومراقبة الرطوبة، وسيتم الإعتماد على نظام إدارة المباني "BMS" واختيار المجسات والمشغلات المناسبة التي تلبي الغرض من المشروع بالإضافة إلى بناء لوحة كهربائية تحتوي على دائرة وأجهزة التحكم ودائرة القدرة التي ستزود المشغلات بالطاقة اللازمة لعملها.

كما وسيتم بناء نظام للتحكم بدرجة الحرارة داخل الغرفة، باستخدام عمليات رياضية داخل نظام إدارة المباني "BMS" وربطها مع المراوح والمسخّنات، عندما تكون درجة الحرارة أقل من درجة الحرارة المطلوبة يتم تشغيل السخّانات عن طريق التعديل النبطي "PWM" إعتماداًعلى درجة الحرارة داخل الغرفة ودرجة حرارة الهواء في الخارج ودرجة الحرارة المرجعية التي يتم ضبطها من المستخدم .

إهداء

إلى معلمنا وقائدنا وحبيبنا وشفيعنا و قدوتنا محمد صلّ الله عليه وسلم.

إلى من رسموا بدمائهم خارطة الوطن وطريق المستقبل وهندسوا بأجسادهم معاقل العزة والكرامة وإلى من هم أكرم منا جميعا شهداء الوطن الحبيب.

إلى الذين عشقوا الحرية التي تفوح منها رائحة الياسمين وتواروا خلف القضبان ليفسحوا لنا النور أسرانا البواسل.

إلى أبي الذي لم يبخل علي يوماً بشيء، وأمي التي زودتني بالحنان والمحبة أقول لهم:

أنتم وهبتموني الحياة والأمل والنشأة على شغف الإطلاع والمعرفة.

إلى إخوتي وأسرتي جميعا.إلى كل من علمني حرفاً أصبح سنا برقه يضيء الطريق أمامي.

إلى من ضاقت السطور لذكرهم فوسعتهم قلوبنا أصدقاؤنا الأعزاء.

إلي كل من أضاء بعلمه عقل غيره، أو هدى بالجواب الصحيح حيرة سائليه، فأظهر بسماحته تواضع العلماء، وبرحابته سماحة العارفين.

إلى من رسم معنا خطوات هذا النجاح الى من بذل جهده ووقتة وكان لنا مرشداً وناصحاً وأخاً مشرفنا الحبيب الأستاذ عبد القادر الزرو.

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Abbreviation Table

Description	Abbreviation
Heating Ventilating and Air Conditioning	HVAC
Building Management System	BMS
Alternating Current	AC
Direct Current	DC
Temperature outdoor	T1
Temperature indoor	T2
Cubic feet per minute	CFM
square feet	ft^2
Centimeter	Cm
Cubic meter	m^3
Pascal	Pa
Newton Meter Square	N/m^2
Automation Server	AS
Programmable Logic Control	PLC
Central Processing Unit	CPU
Input OR Output	I/O
Air Handling Unit	AHU

1

Chapter One

Introduction

1.1 Overview

In this chapter we will talk about the project and the objectives, and make a review lectures for previous project work with the system, in addition we will explain some of HVAC concepts which we will use within this project.

In this section we set the parameters which we need to control with it and element of control system to show where HVAC control required.

1.2 Definition of HVAC system

HVAC abbreviation of (Heating Ventilating and Air Conditioning) it is technology of indoor air quality it's used to reach comfort environmental. By this Technology we control in temperature, humidity, pressure and change air per hour.

The HVAC systems are widely used for they are very important especially in Pharmaceutical manufacturing.

1.3 Objectives

- ✓ Control the temperature degree in the room (22 °C± 2 °C).
- ✓ Control the positive pressure in the room.
- ✓ View the data in computer.
- ✓ Make a calendar and schedule of system.

1.4 HVAC Control System

In this section we will talk about control system with explain why we need automatic control and what parameters are controlled and show where HVAC control required and set the objectives of the control system.

Why Automatic Controls?

The capacity of the HVAC system is typically designed for the extreme conditions. Most operation is part load/off designed as variables such as solar loads, occupancy, ambient temperatures, equipment & lighting loads etc. Keep on changing throughout the day.

1.4.1 What is Parameters are Controlled?

1 **Temperature:** With our system the temperature is critical we must design the system to provide (22 °C ± 2°C).

2 **Ventilation:** ASHRAE standard 62-1999: "ventilation for acceptable indoor air quality" recommends minimum ventilation rates per person in the occupied spaces.

In many situations, local building codes stipulate the amount of ventilation required for commercial buildings and work environments. The recommended value of outside air is typically 20CFM for each occupant.

The ventilation rates specified by ASHRAE effectively dilutes the carbon dioxide and other contaminates created by respiration and other activities; it supplies adequate oxygen to the occupants; and it removes contaminants from the space.

The ventilation rates greater than recommended by ASHARE criteria are sometime required controlling orders and where cooling is not provided to offset heat gains.

3 Pressure: Air moves from area of higher pressure to areas of lower pressure through any available openings. A small crack or hole can admit significant amounts of air, if the pressure differentials are high enough (which may be very difficult to assess).

The rooms and buildings typically have a slightly positive pressure to reduce outside air infiltration.

This helps in keeping the building clean.

i. Where is HVAC Controls Required?

In this project we distributed control system across three areas:

1. The HVAC system equipment and their controls located in the main mechanical room. Equipment includes chillers, boiler, hot water generator, heat exchangers, pumps etc.

2. The weather maker or the "Air Handling Units" which heat, cool, ventilate, or filter the air and then distribute that air to a section of the building. AHU is located in an open area exactly in roof top of the company building.

ii. Objectives of a Control System

Control system in this project is recovering the following objectives:

1) Maintain thermal comfort conditions.
2) Maintain optimum indoor air quality.
3) Reduce energy use.

4) Safe plant operation.
5) To reduce manpower costs.
6) Identify maintenance problems.
7) Efficient plant operation to match the load.
8) Monitoring system performance.

iii. Elements of a control system

HVAC control system in this project has four basic elements: sensor, controller, controlled device and source of energy.

1- Sensor measures actual value of controlled variable such as temperature, pressure or flow and provides information to the controller.
2- Controller receives input from sensor, pressure the input and the produces intelligent output signal for controlled device.
3- Controlled device acts to modify controlled variable as directed by controller.
4- Source of energy is needed to power the control system use either an electric power supply.

1.5 Time Table

Table 1.1: Time Table "First Semester"

Weeks / Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Identification of project idea	■	■	■												
Drafting a preliminary project proposal			■	■											
Introduction about the project (Chapter 1)				■	■	■	■								
General description about project (Chapter2)								■	■	■					
Electrical and Mechanical theory and design (Chapter 3, Chapter 4)											■	■	■	■	■

Table 1.2: Time Table "Second Semester"

Weeks / Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Collect data about the parameter that we will use	■	■	■												
Room prototype manufacturing				■	■	■	■								
Programming and controlling system								■	■	■	■	■			
Collect the electrical and mechanical parts													■	■	
Controlling and monitoring															■

1.6 Literature Review

1.6.1 First Literature

"Building HVAC Systems Control Using Power Shaping Approach"

2016 American Control Conference (ACC) Boston Marriott Copley Place
July 6-8, 2016. Boston, MA, USA
V. Chinde, K. C. Kosaraju, Atul Kelkar, R. Pasumarthy, S. Sarkar, N.M. Singh

Abstract

This literature discuss the theory information about HVAC system and when we use it , and the controller design uses Brayton-Moster formulation for the system dynamics wherein the mixed potential function is the power function.

1.6.2 Second Literature

"Design of an Improved Single Neuron-Based PI Controller for an HVAC System in a Test Room"

2008 International Workshop on Education Technology and Training & 2008 International Workshop on Geoscience and Remote Sensing

Jianbo Bai, Hong Xiao, Tianyu Zhu, Wei Liu, Xianghua Yang, Guofang Zhang
College of Mechanical and Electrical Engineering Hohai University
Changzhou, Jiangsu, China

Abstract

This paper presents an improved single neuron based adaptive PI controller designed for regulation a heating , ventilation and air condition , the proportional coefficient of the neuron can be adjusted in real-time based on a single neuron.

2

Chapter Two

Theory

2.1 Overview

In this chapter we insert the most equipment, which may be component for HVAC system clarification it is characteristic, functions and how to operate it, and we talk about the methods and types of control in HVAC system.

2.2 Heating Source Components

Heating systems help to ensure the thermal comfort of the inhabitants of buildings by meeting the heat demand created by heat transmission and ventilation losses.

2.2.1 Heat Pumps

Heat pumps are just two-way air conditioners during the summer, an air conditioner works by moving heat from the relatively cool indoors to the relatively warm outside. In winter, the heat pump reverses this trick, scavenging heat from the cold outdoors with the help of an electrical system, and discharging that heat inside the house. Almost all heat pumps use forced warm-air delivery systems to move heated air throughout the house.

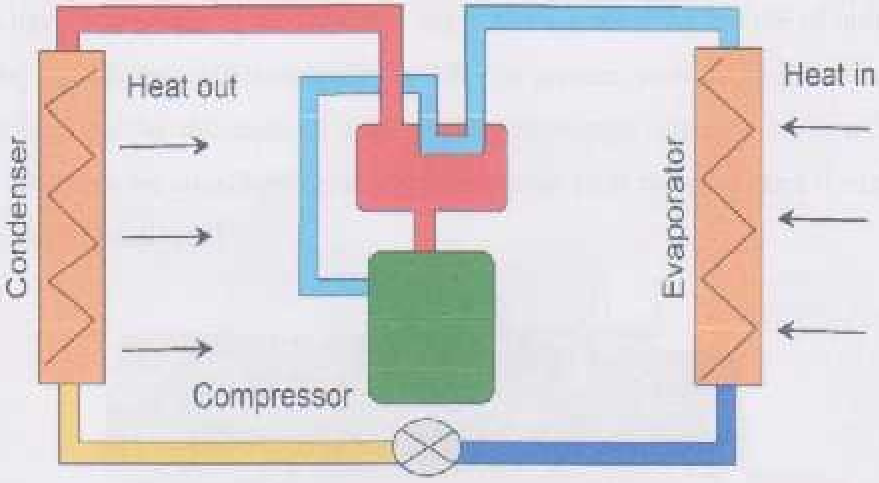

Figure (2.1) Heat Pump

There are two relatively common types of heat pumps. Air-source heat pumps use the outside air as the heat source in winter and heat sink in summer. Ground-source (also called geothermal, GeoExchange, or GX) heat pumps get their heat from underground, where temperatures are more constant year-round. Air-source heat pumps are far more common than ground-source heat pumps because they are cheaper and easier to install. Ground-source heat pumps, however, are much more efficient, and are frequently chosen by consumers who plan to remain in the same house for a long time, or have a strong desire to live more sustainably. How to determine whether a heat pump makes sense in your climate is discussed further under "Fuel Options." [1]

2.2.2 Boilers

Boilers are special-purpose water heaters. While furnaces carry heat in warm air, boiler systems distribute the heat in hot water, which gives up heat as it passes through radiators or other devices in rooms throughout the house. The cooler water then returns to the boiler to be reheated. Hot water systems are often called hydraulic systems. Residential boilers generally use natural gas or heating oil for fuel. [1]

Boilers have several strengths that have made them a common feature of buildings. They have a long life, can achieve efficiencies up to 95% or greater, provide an effective method of heating a building, and in the case of steam systems, require little or no pumping energy. However, fuel costs can be considerable, regular maintenance is required, and if maintenance is delayed, repair can be costly. [2]

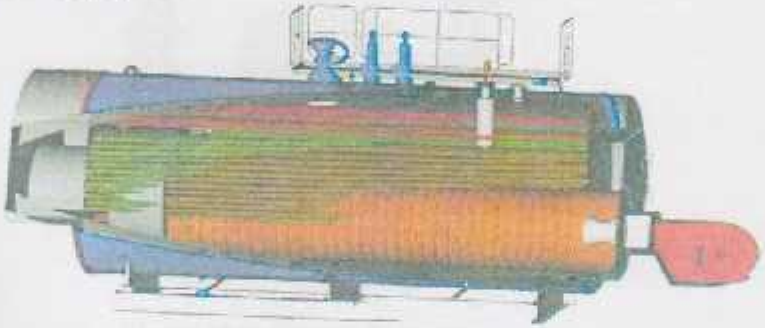

Figure (2.2) Boiler

2.2.3 Electric Resistance Heating

Energy is converted to heat. However, most electricity is produced from coal, gas, or oil Electric resistance heating is 100% energy efficient in the sense that all the incoming electric generators that convert only about 30% of the fuel's energy into electricity. Because of electricity generation and transmission losses, electric heat is often more expensive than heat produced in homes or businesses that use combustion appliances, such as natural gas, propane, and oil furnaces.

Electric resistance heating may also make sense for a home addition if it is not practical to extend the existing heating system to supply heat to the new addition. [3]

Electric resistance heat continues to be a popular choice with consumers and commercial users for good reason. It is affordable, efficient, clean, and comfortable, to name just a few of its many qualities. Moreover, ERH is uniquely situated to assist in the deployment of greater amounts of electricity generated from renewable energy sources like wind and solar power. As with the electric car, consumer consciousness surrounding the use of clean electricity is growing exponentially, and it is reasonable to think that favorable attitudes toward electric heating will grow accordingly.

It's easy to see why the future of electric resistance heating is so bright because it provides small and large-scale solutions for many of the world's energy challenges. [4]

Figure (2.3) Electric Resistance

2.3 Air Distribution System Components

Air-distribution systems include air handlers, ductwork, and associated components for heating, ventilating, and air-conditioning buildings. They provide fresh air to maintain adequate indoor-air quality while providing conditioned air to offset heating or cooling loads. Their many components need to operate in unison to properly maintain desired conditions. They use relatively large amounts of energy so applying smart operational strategies and good maintenance practice can significantly reduce energy consumption. [5]

2.3.1 Ductwork

The ductwork that is used to achieve the delivery of air from the equipment to the room can have a great impact on comfort in the room. The capacity of a duct to carry air is affected by the resistance within the duct.

The success of a design in either flexible duct or rigid duct depends upon the faithful execution of the design during installation. [6]

Figure (2.4) Duct

Benefits of Properly Designed & Installed Duct System [7]

- Adequate air flow.
- Less conditioned air leakage.
- Higher energy efficiency.
- Smaller, less expensive equipment.
- Longer equipment service life.
- Healthier, safer indoor air quality.
- Greater comfort for occupants.

2.3.1 Air Handling Unit

An Air Handling Unit (most of the times abbreviated to AHU), or Air Handler, is a central air conditioner station that handles the air that, usually, will be supplied into the buildings by the ventilation ductwork (connected to the AHU).

Handling the air means that the air will be delivered into the building spaces with thermo-hygrometric and IAQ (Indoor Air Quality) treatment. The accuracy of the treatment will depend from the specificity of each project (offices, schools, swimming-pools, laboratories, factories with industrial processes, etc.

This means, the Air Handling Unit treat the air by filtering, cooling and/or heating, humidifying and/or dehumidifying.

There are several types of Air Handling Units: Compact, Modular, Residential, DX integrated, Low Profile (ceiling), Packaged, Rooftop mounted (typically on the roofs of buildings, with special weather protection), etc. [8]

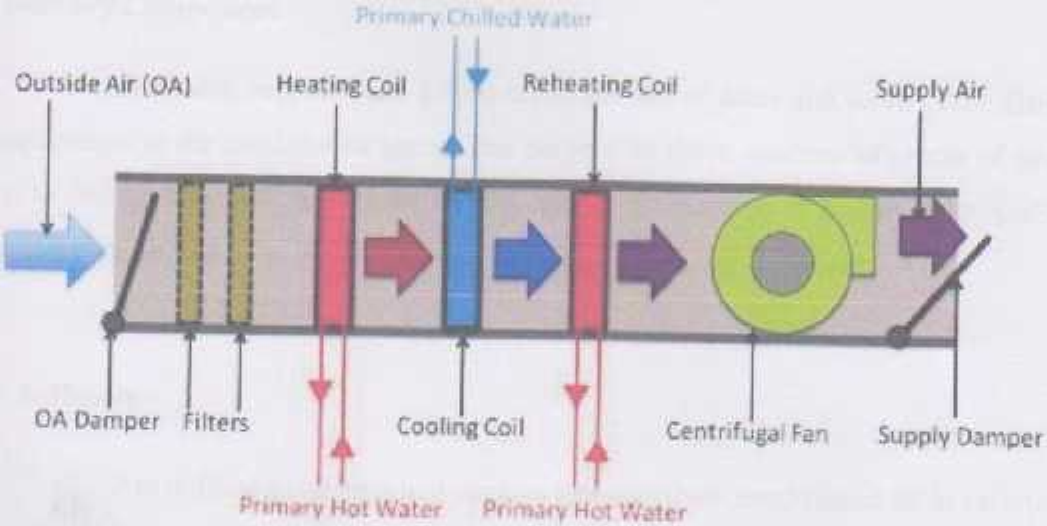

Figure (2.5) Air Handling Unit

Components:

Some of the most known components are: [8]

- Fans (Plug Fans, Double Inlet, Single Inlet, Axial, etc.
- Filters (Plate Filters, Bag Filters, Compact Filters, EPA Filters, HEPA Filters, ULPA Filters, and Carbon Filters).
- Cooling/Heating Coils (water/steam/Direct Expansion DX/electric/gas fired).
- Heat recovery systems (cross flow plate heat exchangers, cross flow plate heat exchangers, heat wheel/rotating heat exchangers, run around coils and heat pipes, etc.
- Humidifiers (Adiabatic/Evaporative Pad, non-pressurized Steam, pressurized steam).
- Dehumidifiers (DX coil, desiccant rotor).
- Ultraviolet UV disinfection lamps.
- Photo catalytic oxidation (PCO) air cleaners.
- Sound attenuators.
- Mist/Droplet eliminators.
- Dampers.

2.4 Delivery Component

Diffusers, registers and grilles are at the end of ducts and serve as the distribution equipment to the conditioned space. The purpose of these mechanical pieces of equipment is to provide thermal comfort for the occupants of the space or to provide proper thermal conditions suitable for the equipment in the space.

2.4.1 Diffusers

Are defined as air terminal devices that distribute conditioned air in various directions through the use of its deflecting vanes. It is designed to promote the mixing of conditioned air with the air already in the space. It is important to properly mix the conditioned air into the space, in order to provide cooling/heating and to distribute fresh air to the entire space and to avoid stagnant air in the space. [9]

Figure (2.6) Diffusers

2.4.2 Grilles

Are defined as air devices that consist of an opening with a covered grating or screen. Grilles are often used to return air back to the fan or to exhaust air from a space. Grilles are not typically used to supply air because there is an inability to accurately control the amount of air being supplied. [9]

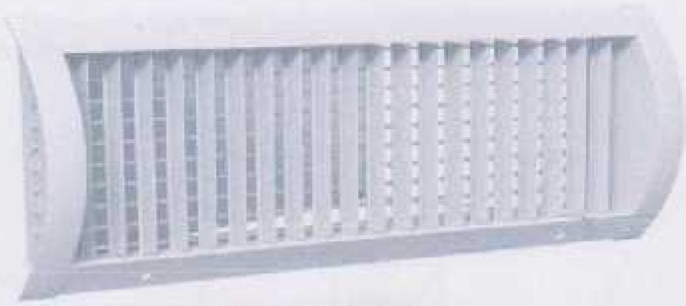

Figure (2.7) Grilles

2.4.3 Registers

Are simply grilles with a damper that is used to restrict the amount of air flow required to be returned, supplied or exhausted. [9]

Figure (2.8) Registers

2.5 HVAC Controls

The control system in the Heating, Ventilating, and Air- Conditioning (HVAC) system can have a significant impact on the building's comfort and energy consumption. The control system manages the flow of heat, cooling, and ventilation throughout the building.

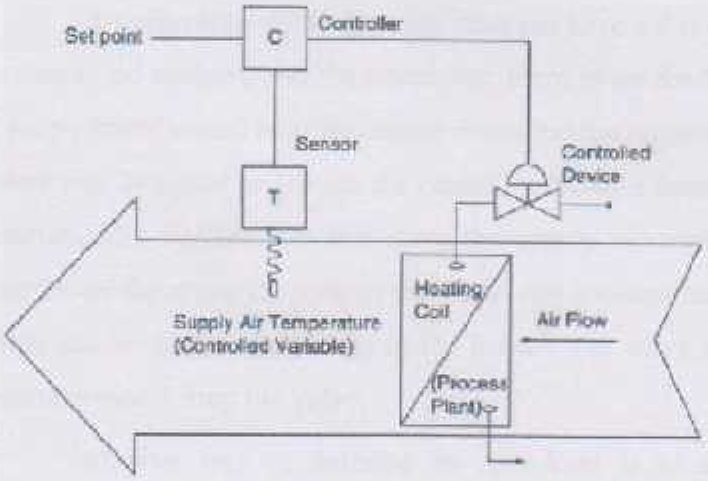

Figure (2.9) Simple Heating System

2.5.1 Theory of Controls

Basically there are two types of controls viz open and close loop control.

Figure (2.10) below illustrates a basic control loop for room heating. In this figure the thermostat assembly contains both the sensor and the controller. The purpose of this control loop is to maintain the controlled variable (room air temperature) to some desired value, called a set point. Heat energy necessary to accomplish the heating is provided by the radiator and the controlled device is the 2-way motorized or solenoid valve, which controls the flow of hot water to the radiator. [10]

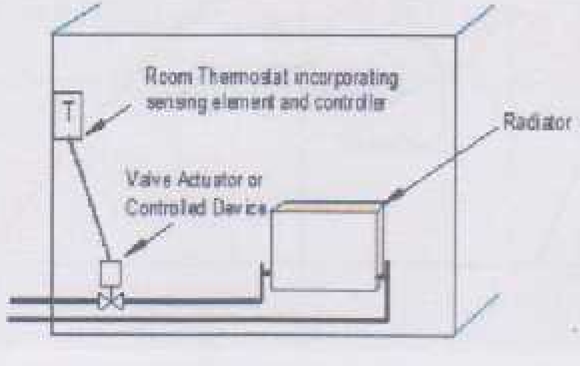

Figure (2.10) Room Temperature Control

2.5.1.1 Open Loop Control

A control loop where the sensor is measuring something other than the controlled variable. Changes to the controlled device and process plant have no direct impact on the controlled variable. There is an "assumed" relationship between the property that is measured and the actual variable that is being controlled.

An open-loop control system does not have a direct link between the value of the controlled variable and the controller: there is no feedback. An example of an open- loop control would be if the sensor measured the outside air temperature and the controller was designed to actuate the control valve as a function of only the outdoor temperature. The variable (in this case, the supply air temperature or perhaps the temperature of the space the system served) is not transmitted to the controller, so the controller has no direct knowledge of the impact that valve modulation has on these temperatures modulating the valve.

Another way of defining an open-loop is to say that changes to the controlled device (the control valve) have no direct impact on the variable that is sensed by the controller (the outdoor air temperature in this case). With an open-loop control system, there is a presumed indirect connection between the end-result and the variable sensed by the controller.

If the exact relationship between the outdoor air temperature and the heating load was known, then this open-loop control could accurately maintain a constant space temperature. In practice, this is rarely the case and, therefore, simple open-loop control seldom results in satisfactory performance [11].

Figure (2.11) Relationship between Temperature &Time

2.5.1.2 Closed Loop Control

A closed loop control where the sensor is measuring the value of the controlled variable, providing feedback to the controller of the effect of its action.

In general ask a question, does sensor measure controlled variable? If yes the control system is closed loop, if not the system is open loop.

The purpose of any closed-loop controller is to maintain the controlled variable at the desired set point. All controllers are designed to take action in the form of an output signal to the controlled device. The output signal is a function of the error signal, which is the difference between the control point and the set point. The type of action the controller takes is called the control mode or control logic, of which there are three basic types:

- Two-position control
- Floating control
- Modulating control

Almost all HVAC continuous control systems use closed control loops. [11]

2.5.2 Elements in any Control Loop

- **Controlled Variable:** The property that is to be controlled, such as temperature, humidity, velocity, flow and pressure.
- **Control Point:** The current condition or value of the controlled variables set point, the desired condition or value of the controlled variable.
- **Sensor:** The device that senses the condition or value of the controlled (or "sensed") variable.
- **Sensed Variable:** The property (temperature, pressure, humidity) that is being measured.
  Usually the same as the controlled variable in closed-loop control systems.
- **Controlled Device:** The device that is used to vary the output of the process.

plant, such as a valve, damper, or motor control.

- **Process Plant:** The apparatus or equipment used to change the value of the controlled variable, such as a heating or cooling coil or fan.
- **Controller:** The device that compares the input from the sensor with the set point, determines a response for corrective action, and then sends this signal to the controlled device.
- **Control Loop:** The collection of sensor, controlled device, process plant, and controller. [11]

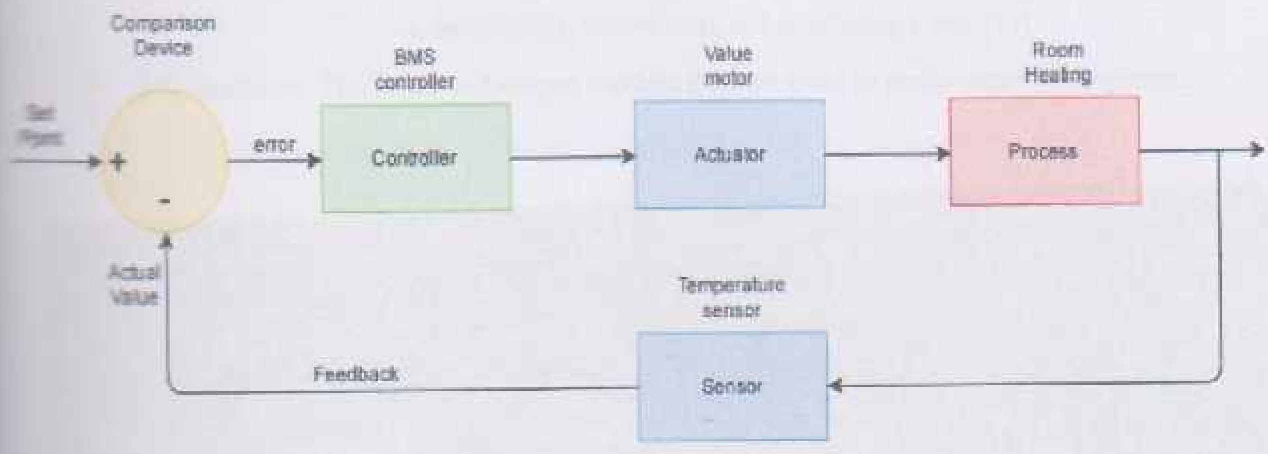

Figure (2.12) Closed loop for Temperature

2.6 Building Management System

What is the BMS?

Building Management System which deals with control, parameter measurement and central control of all building facilities through one central station. [12]

Where the BMS is used: Building management systems are most commonly implemented in large projects with extensive mechanical, HVAC, electrical systems.

Why we use BMS system?

We use BMS system because many reasons:

- Possibility of individual room control
- Effective response to HVAC related complaints
- Most commonly implemented to HVAC

What we need to make BMS system?

We need this component:

- **Power Supply:** The PS-24 is a power supply module that requires 24 VAC or 24 VDC input power.[13]
- **Automation Server:** Is Server can perform all the key functions for engineering, commissioning, supervising, and monitoring a site. [13]
- **I/O modules:** The input and output module that we need to make controlled system.

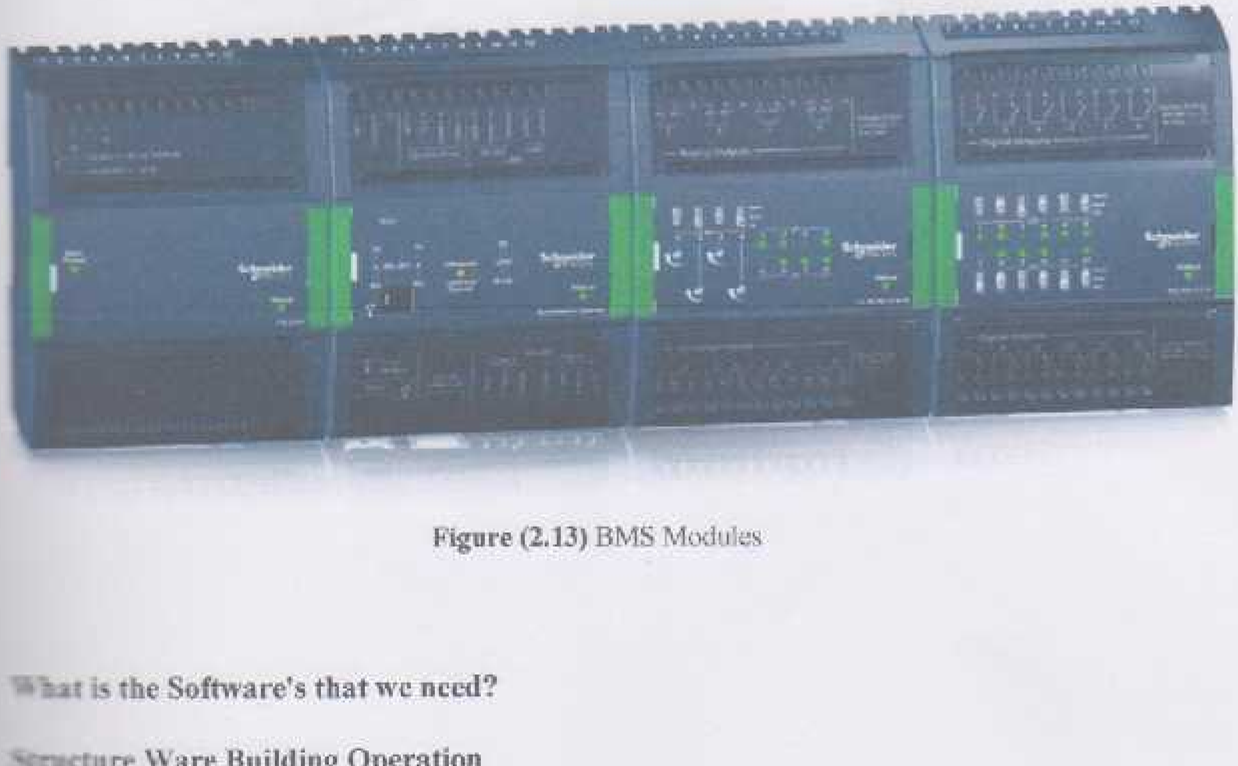

Figure (2.13) BMS Modules

What is the Software's that we need?

Structure Ware Building Operation

Smart Structure ™ solution enables you to monitor, measure, and optimize your building's performance throughout its life cycle — saving energy while saving money. Because you can't control what you don't measure, Smart Structure solution facilitates the exchange and analysis of data from energy, lighting, fire safety and HVAC. [14]

Enterprise Server

Global view of the system the entire system, including all of the Automation Servers and their associated devices, can be accessed and configured through the Enterprise Server. [15]

Figure (2.14) Smart Structure Solution

How Does BMS Work?

- System Interface an application for the user allowing interaction with the system.
- Master controllers to manage system functions and data flow.
- Field controllers to monitor input signals and deliver output signals in response to logic calculations
- Field sensors that send signals to controllers, Controlled devices that receive signals from controllers. [16]

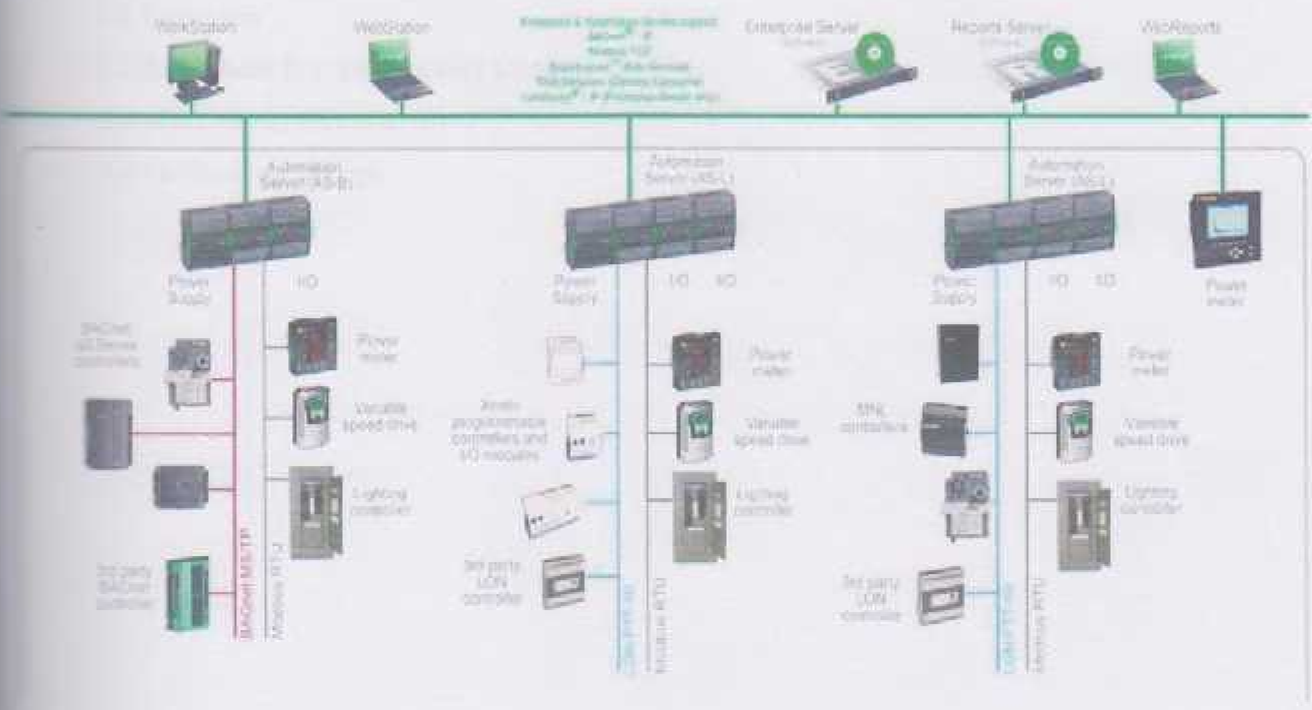

Figure (2.15) BMS Architecture

3

Chapter Three

Mechanical Design

3.1 Overview

How this system will be work and what procedure will be following figure (3.1) and figure (3.2) show flowchart for the system, and by tracking this diagram we will be able to identify an approach of this system.

3.2 Flowchart for Parameters Control

1) Monitoring the pressure: the pressure enters the room must be positive and the out of the room must be negative; because the air flow transported from positive to negative area.

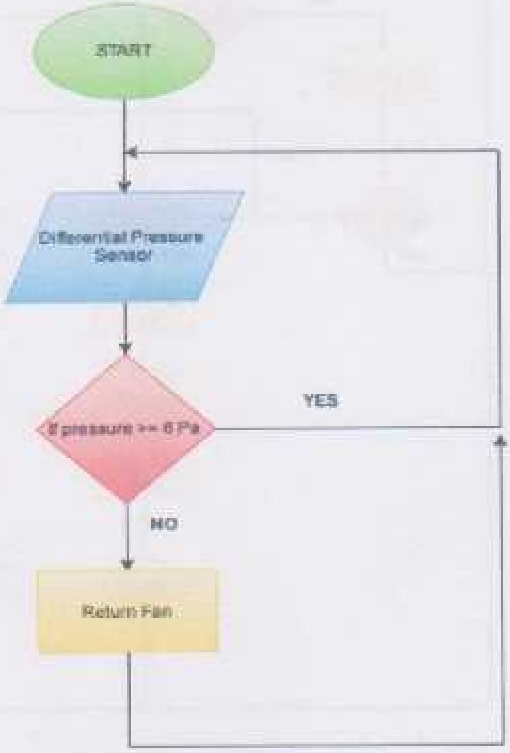

Figure (3.1) Flowchart of Pressure

2) Monitoring the temperature: by temperature sensor we can monitor space, fresh air temperature. With BMS by using actuators we can keep the temperature with set value 22°C from figure (3.1) we can see if the space temperature less than or greater than 22°C the system will take action by operating heater with refresh fan or by refresh fan with return fan only , and we design the following flow chart to explain this process.

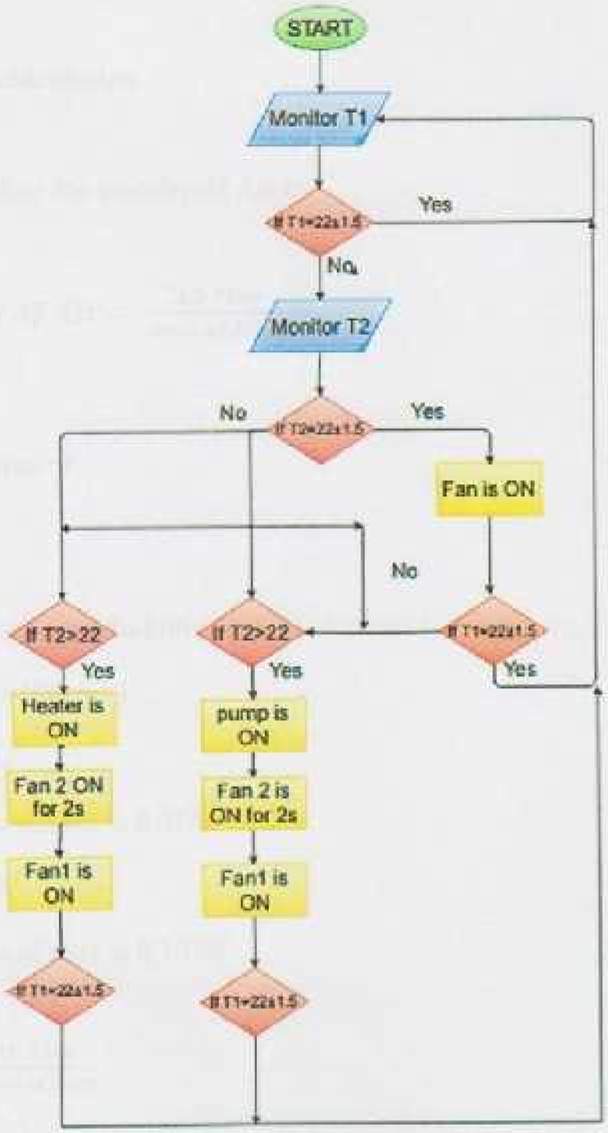

Figure (3.2) Flowchart of Temperature

3.3 Mechanical Calculation

3.3.1 Data for Design

Before design we let the airflow is 1 CFM and the dimension of duct is 10*10 cm and the dimension of room is (50*50*50) cm.

3.3.2 Equation and calculation

We can calculate the velocity of Air by:

$$Velocity\ of\ Air = \frac{Air\ Flow}{Area\ of\ Ducts} \qquad \text{.............................(1)}$$

Where:

Airflow in (CFM) Area of duct in (ft.^{2})

Area of duct = length*width ....(2)

Area of duct =100cm^2 1

m^2= 10000cm^2

Then the area of duct is 0.01m^2

1m^2=10.761ft^2

Then the area of duct is 0,107ft^2

$$Velocity\ of\ Air = \frac{Air\ flow}{Area\ of\ Duct}$$

Velocity of air is 9.292 ft /min or 2.8959 m/min

We can calculate the Air change per hour by:

$$\textbf{Velocity of Air} = \frac{Air\ flow*60}{\text{Area of Duct}} \qquad \ldots\ldots(3)$$

Where:

Airflow in (CFM) Room volume in (ft^3)

Volume of room = width*length *height ....(4)

Volume of room = 50*50 *50

Volume of room = 100000 cm^3

Volume of room is 3.3026 ft^3

$$\textbf{Velocity of Air} = \frac{Air\ flow*60}{\text{Area of Duct}}$$

$$\textbf{Velocity of Air} = \frac{1*60}{\text{Room Volume}}$$

Air change per hour = 18 CFM

We can calculate the power of Fan by:

Power of fan = airflow * Static pressure

Where:

Velocity of Fan in (m^3/s)

Static presser in (Pa, N/m2)

From figure (3.3) we can conclude the static pressure

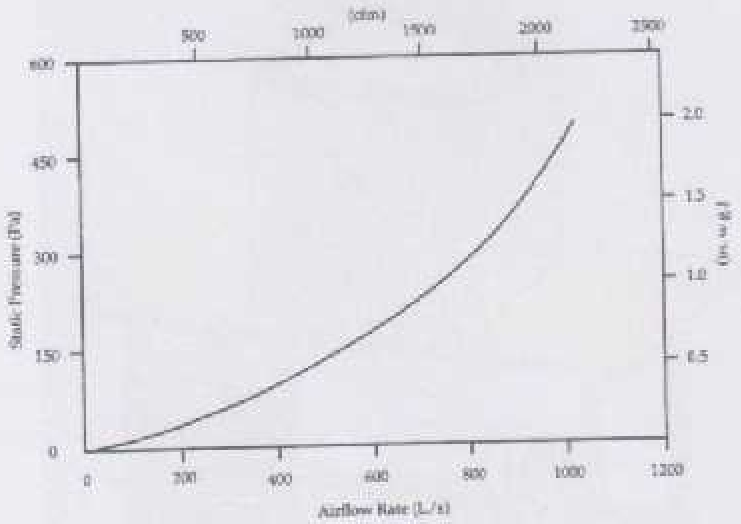

Figure (3.3) Pressure Drop versus Air Flow Rate

Static pressure = 0.000204186

Power of fan = Airflow * Static pressure

1CFM = 0.00475 m^3/s

Airflow = 2119.31 m^3/s

Power of fan = 21191.31*0.000204186

Power of fan = 4.32 W.

When we search about Fan we found fan with power 5 W.

3.4 Mechanical Design

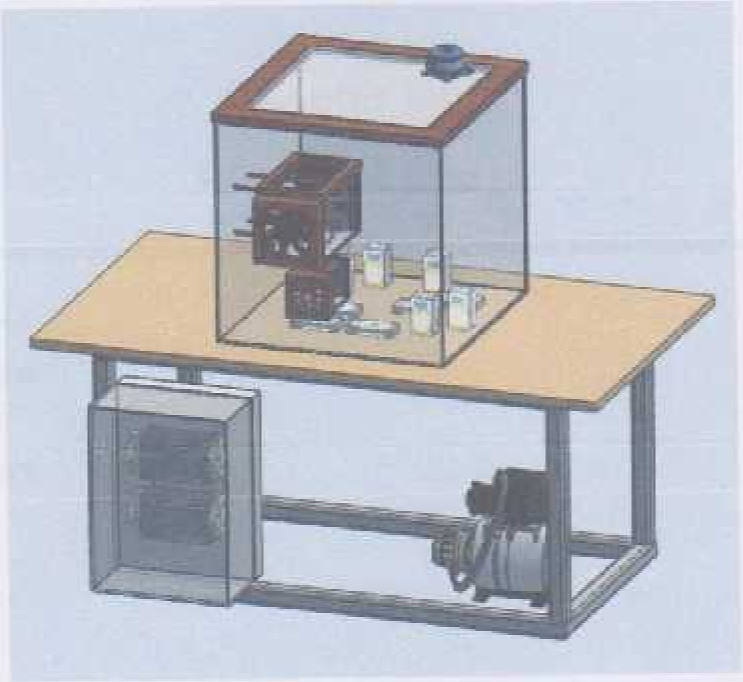

Figure (3. 4) All Sides for Design

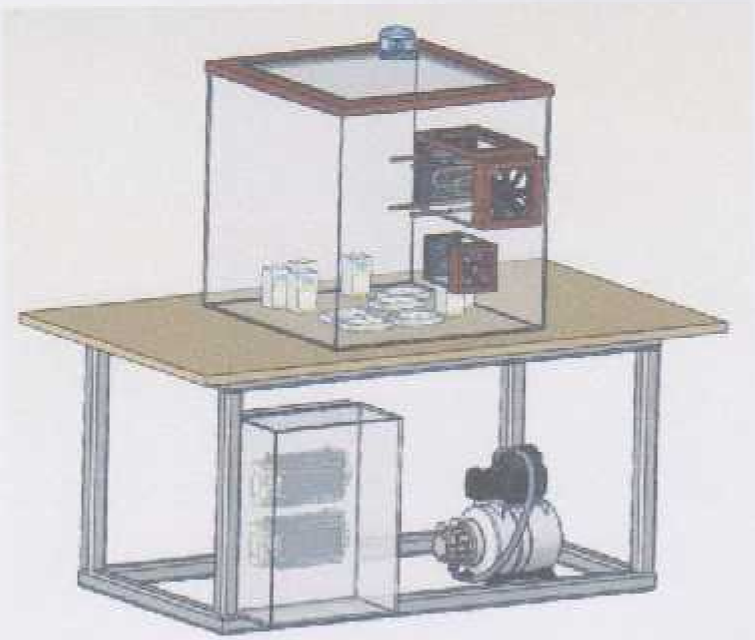

Figure (3. 5) Front View for Design

4

Chapter Four

Electrical Design

4.1 Overview

In this chapter we will talk about BMS system and electrical circuit and control methods during this project, as we talked in previous chapter what parameter we want to control and main component of this project. Now we will insert how who we controlled with these parameter and what is the methods we followed to keep set value in this system.

4.2 Controller

The Automation Server:- is server can perform all the key functions for engineering, commissioning, supervising, and monitoring a site but the Automation server is not controller but act as controller.[2]

In the BMS system the automation server represented CPU in PLC system because that automation server needed also some equipment to control and monitoring like "power supply, I/O modules, and rack for feeding and communication ".

Figure (4.1) Automation Server

Table (4.1) Control Device

Name	Description	Module number
Power Supply	The PS-24 is a power supply module that requires 24 VAC or 24 VDC input power.	SXWPS24VX10001
AUTMATION SERVER	can perform all the key functions for engineering, commissioning, supervising, and monitoring a site	SXWASBXXX10001
UI-8/DO-FC-4-H	8 Universal Inputs & 4 Digital Outputs(Form C) with hand control/override	SXWUI8D4H10001
TB-AS-W1	Terminal Base AS (Terminal base required for each Automation Server: AS-B or AS-L)	SXWTBASW110001
TB-PS-W1	Terminal Base Power Supply (Terminal Base required for each power supply)	SXWTBPSW110001
TB-IO-W1	Terminal Base I/O (Terminal Base required for each I/O module)	SXWTBIOW110001

Figure (4.2) Terminal Base

4.3 Sensors

Sensor is used to send actual values of parameters in the process to BMS, in this project we used group of sensor with varies type, characteristic and function. At the follow we show this sensor and its position in the system.

4.3.1 Temperature Sensor

In previous chapter we show that the most important parameter in HVAC system is temperature .And we will to keep the temperature in the room nearest to set value.

Table (4, 2) Temperature Sensor

Sensor name	Manufacturer	Module number	Type	Position
Space temp. Sensor	Schneider	STX520	RTD	Conditioned zone
Supply air temp. Sensor	Schneider	STX520	RTD	Outlet AHU

Space and supply air temperature Sensors are used to measure conditioned space temperature and supply air temperature for control and monitor with procedures show in flowchart figure (3.2).

4.3.2 Pressure Sensor

The pressure in room usually slightly positive pressure from outdoor, because that we used high pressure switch to satisfy this statement.

Table (4.3) Pressure Sensor

Sensor name	Manufacturer	Module number	Position
High pressure switch	Kimo	LGV 300 HC2	In and out room

4.4 Actuators

By send a control signal to this device from BMS system we will able to control the variable parameter, table (4.4) show the actuators in this project and a position in this system.

Table (4.4) Actuators

Name of actuator	Manufacturer	Module number	Position
Refresh fan	Delta	Afb1312m-sm02	In AHU
Return fan	Hstar2	HQ CY615/A	In the Room
Heat element	-	-	In the AHU

5

Chapter Five

Practical and Evaluating

5.1 Introduction

In this chapter provides experimental result and some recommendations from the work learned from this project by using programming techniques and combination electrical parts, and listing some goals hope to be accomplished or at least under attention.

5.2 Experimental Result

1. At the first when the system is running the temperature sensor outside the room read the actual temperature and compares it with the reading temperature sensor inside room based on that the system run pump "chiller" or heater.

2. While the system is running the differential pressure sensor compare the pressure inside the room with outside the room, the system treating the pressure issue.

3. For cooling we were using fans only, but we found that it was not achieving the desired results, based on that we added the aluminium tube to passes the water for fast cooling.

5.3 Programming of BMS

At the end of project and the completion of the connection control and power circuit properly, we have run BMS System and graphic of this project, to test the project and we have run Modelling of HVAC system automatically and manual by using graphic interface the system work as follows:

5.3.1 Interface for Program

This interface for program in BMS to control and monitoring of HVAC system by using push button for controlling and gages for monitoring.

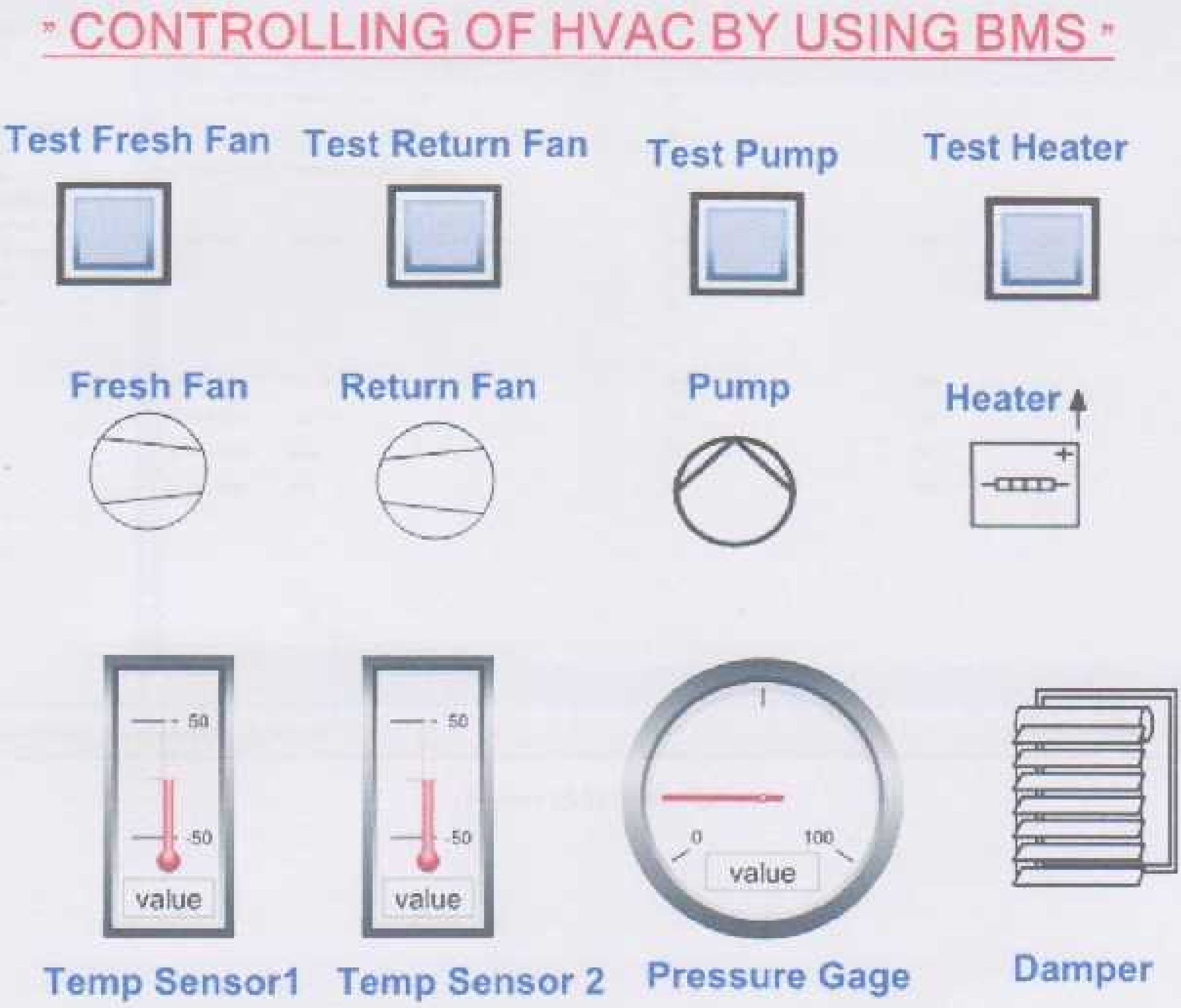

Figure (5.1) Controlling of HVAC by using BMS

5.3.2 Inputs and Outputs

The following figure is a spread sheet, we defined all the inputs and outputs for the system and monitoring if the system is working or not.

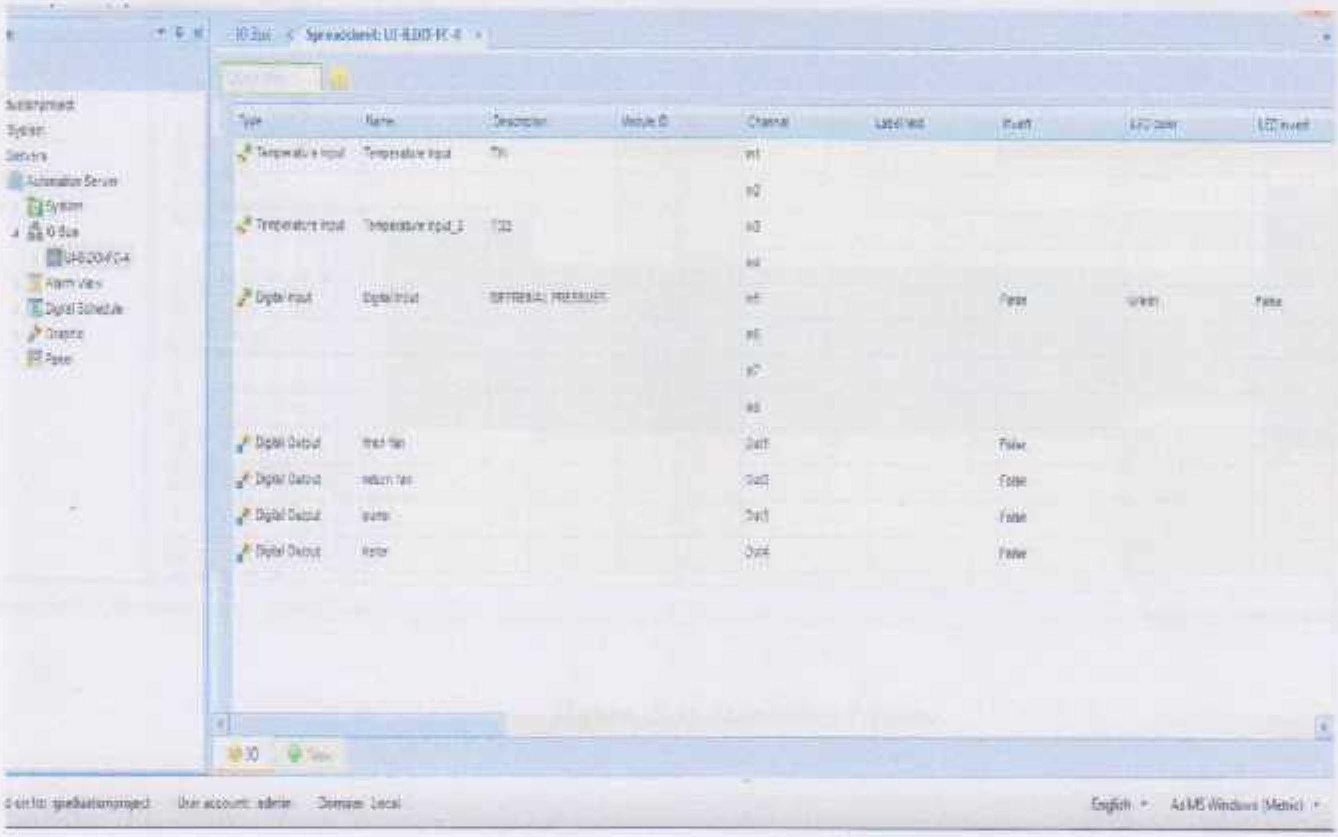

Figure (5.2) Spread Sheet

5.3.3 Time Schedule

In the scheduling process, we can specify the working hours of the system, in addition to that we can specify the holidays on which the system will not work.

Figure (5.3) Scheduling Process

5.4 Project Cost

Table (5.1) Cost Table

Name	Number of part	Cost	Total
Power supply	1	1250 ₪	1250₪
Automation server	1	3000₪	3000₪
Ui-8/do-fc-4-h	1	1500₪	1500₪
Tb-as-w1	3	300 ₪	900₪
Temperatures sensor	2	200₪	400₪
Differentia pressure sensor	1	400₪	400₪
Refresh fan	1	50₪	50₪
Retune fan	1	50₪	50₪
Cooling coil	1	180₪	180₪
Heater	1	70₪	70₪
Mechanical implementation	1	500₪	500₪
Electrical panel and equipment	1	300₪	300₪
		Total	**9000₪**

5.5 Recommendations

1. **Companies and factories**

"HVAC system which we have built modelling of machine in this project we built modelling of HVAC system, this system can implement on large area of industrial factory like pharmaceutical industry or hospital. And we can replace the central air condition to HVAC at any building.

2. **Development and Expansion**

In this project we built the system and run the modelling of machine and built monitor by using BMS system and in the future we can add new system to BMS like lighting system and door control ...etc.

BMS system gives amiability to monitoring the system from office that mean online monitoring and by using internet network.

In our project we used the glass material; however we recommend using insulating materials that are not affected by surrounding factors.

We advise using BMS although the high cost because most commonly implemented in large projects with saving energy.

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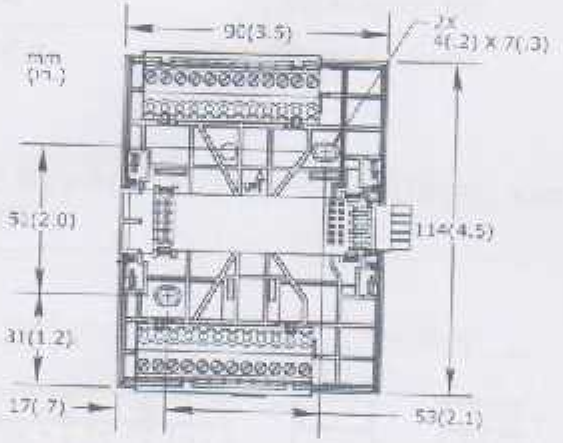
Appendix A

Automation Server Family

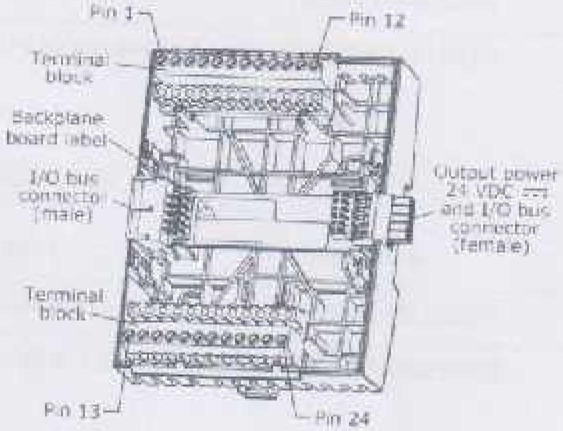
Installation Instructions

Terminal Base TB-IO-W1

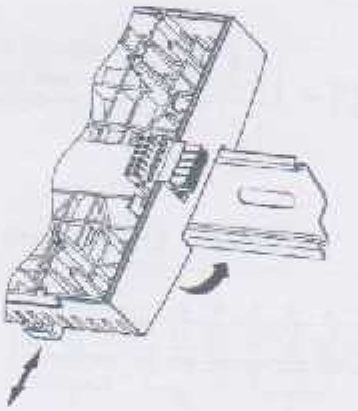
Dimensions



Overview

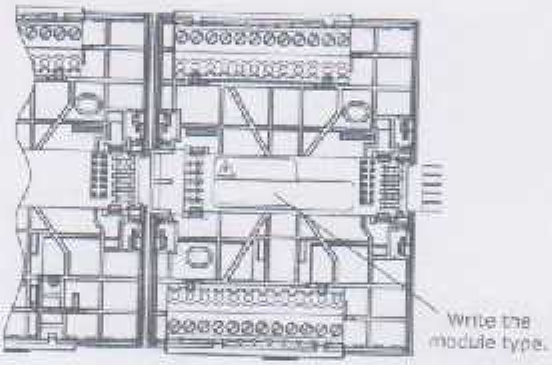


Installing the Terminal Base



Caution: Install the terminal base vertically for proper ventilation.

Connecting the Next Terminal Base



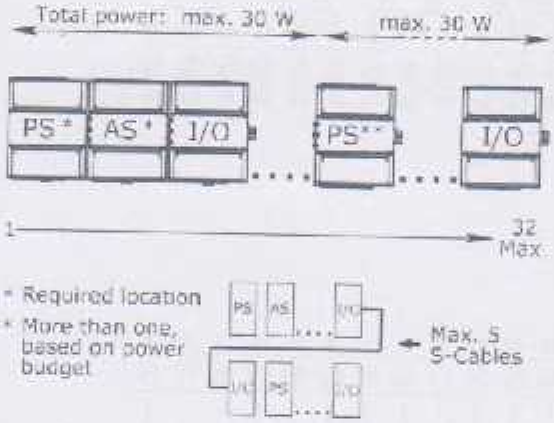
Warning: Ensure that the module type and the terminal base type match. A mismatch can cause electric shock and damage the module.

Schneider Electric

Devices that Use this Terminal Base (-H indicates Override Switch)

Device	Part number
DI-16	SXWDI16XX10001
UI-16	SXWUI16XX10001
DO-FA-12	SXWDOA12X10001
DO-FA-12-H	SXWDOA12H10001
DO-FC-8	SXWDOC8XX10001
DO-FC-8-H	SXWDOC8HX10001
AO-8	SXWAO8XXX10001
AO-8-H	SXWAO8HXX10001
AO-V-8	SXWAOV8XX10001
AO-V-8-H	SXWAOV8HX10001
UI-8/DO-FC-4	SXWUI8D4X10001
UI-8/DO-FC-4-H	SXWUI8D4H10001
UI-8/AO-4	SXWUI8A4X10001
UI-8/AO-4-H	SXWUI8A4H10001
UI-8/AO-V-4	SXWUI8V4X10001
UI-8/AO-V-4-H	SXWUI8V4H10001

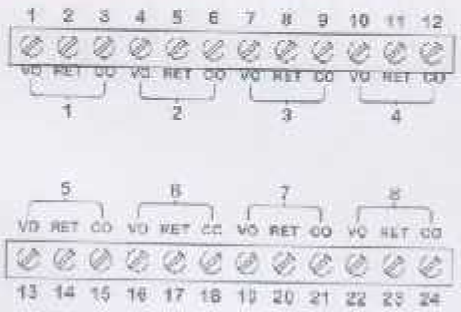
I/O Bus Addressing, Power Limits, and Cables



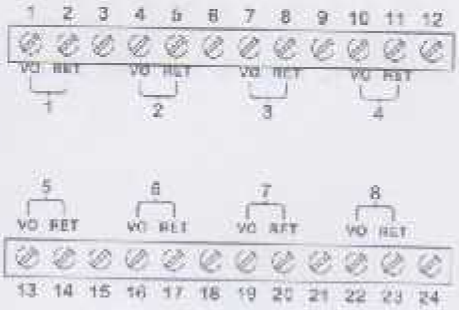
S-Cables

Device	Part number
S-Cable, 1.5 m, straight	SXWSCABLE10001
S-Cable, 1.5 m, angle	SXWSCABLE10002

Connections for I/O Modules

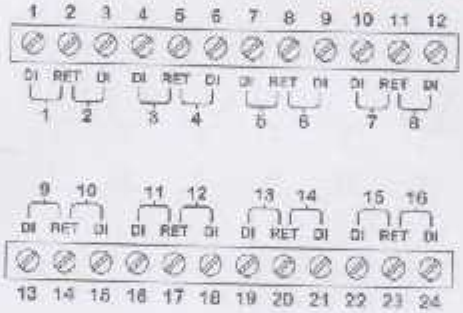


AO-8(-H)

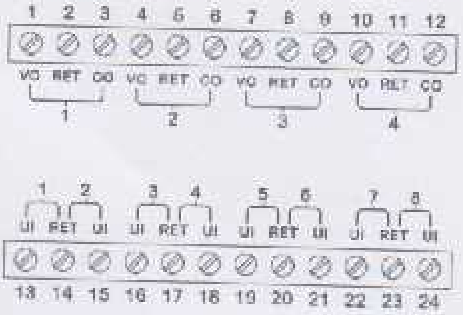


AO-V-8(-H)

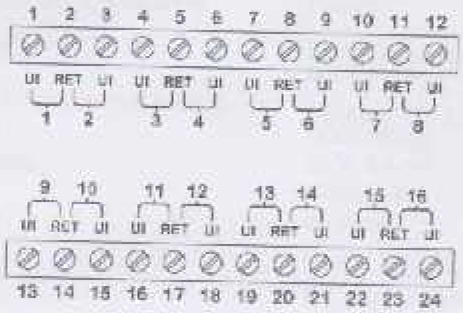
DI-16



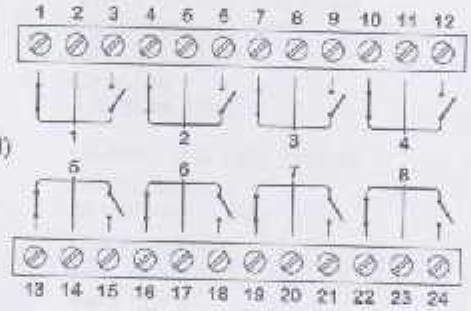
UI-8/
AO-4(-H)



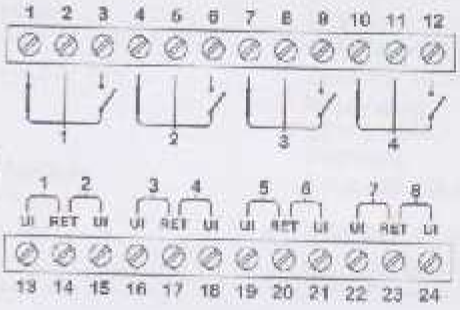
UI-16



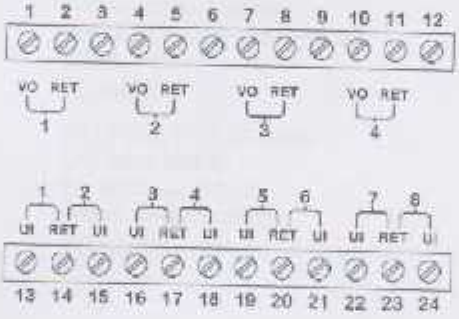
DO-FC-8(-H)



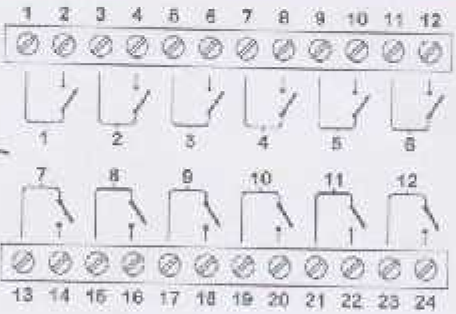
UI-8/
DO-FC-4(-H)



UI-8/
AO-V-4(-H)



Connections for I/O Modules, continued



Specifications

Operation environment

Ambient temperature, operating

0 to 50 °C (32 to 122 °F)

Humidity

Maximum 95 % RH non-condensing

Mechanical

Enclosure rating

IP 20

Plastic rating

UL94-5VB

Electrical

I/O bus power

24 VDC ⎓, max. 30 W per I/O bus power supply, Class 2

Maximum addresses per I/O bus

32

AO-8 (-H) Module

DC input power

24 VDC ⎓, 4.9 W

Output rating

0 to 10 VDC ⎓, 0 to 20 mA

Channels

8 output

AO-V-8 (-H) Module

DC input power

24 VDC ⎓, 0.7 W

Output rating

0 to 10 VDC ⎓

Channels

8 output

DI-16 Module

DC input power

24 VDC ⎓, 1.6 W

Input rating

24 V, 2.4 mA

Channels

16 input

UI-16 Module

DC input power

24 VDC ⎓, 1.8 W

Input rating

24 V, 2.4 mA

Channels

16 input

UI-8/DO-FC-4 (-H) Module

DC input power

24 VDC ⎓, 1.9 W

Relay contact rating

250 VAC ∿ /30 VDC ⎓, 3 A

Input rating

24 V, 2.4 mA

Channels

4 output/8 input

UI-8/AO-4 (-H) Module

DC input power

24 VDC ⎓, 3.2 W

Output rating

0 to 10 VDC ⎓, 0 to 20 mA

Input rating

24 V, 2.4 mA

Channels

4 output/8 input

UI-8/AO-V-4 (-H) Module

DC input power

24 VDC ⎓, 1.0 W

Output rating

0 to 10 VDC ⎓

Input rating

24 V, 2.4 mA

Channels

4 output/8 input

DO-FA-12(-H) Module

DC input power

24 VDC ⎓, 1.8 W

DO-FA-12(-H)

Relay contact rating

250 VAC ∿ /30 VDC ⎓, 2 A

Channels

12 output

DO-FC-8 (-H) Module

DC input power

24 VDC ⎓, 2.2 W

Relay contact rating

250 VAC ∿ /30 VDC ⎓, 3 A

...atory Notices

Federal Communications Commission

...Rules and Regulations CFR 47, Part 15, Class B

...device complies with part 15 of the FCC Rules. Operation is subject to the following two ...ditions: (1) This device may not cause harmful interference. (2) This device must accept any ...erference received, including interference that may cause undesired operation.

...stry Canada

...ES-003

...is a Class B digital device that meets all requirements of the Canadian Interference Causing ...ment Regulations.

C-Tick (Australian Communications Authority (ACA))

...NZS 3548

...equipment carries the C-Tick label and complies with EMC and radio communications regulations ...the Australian Communications Authority (ACA), governing the Australian and New Zealand (AS/NZS) ...munities

CE- Compliance to European Union (EU)

2004/108/EC Electromagnetic Compatibility Directive

This equipment complies with the rules, of the Official Journal of the European Union, for governing the Self Declaration of the CE Marking for the European Union as specified in the above directive(s) per the provisions of the following standards: IEC/EN 61326-1 Product Standard, IEC/EN 61010-1 Safety Standard

WEEE - Directive of the European Union (EU)

This equipment and its packaging carry the waste of electrical and electronic equipment (WEEE) label in compliance with European Union (EU) Directive 2002/96/EC, governing the disposal and recycling of electrical and electronic equipment in the European community.

UL 916 Listed products for the United States and Canada, Open Class Energy Management Equipment.

Appendix B

SPD900
Pressure Switches

SPD900

The SPD differential pressure switch is intended for use in air handling systems for the monitoring of air ducts, fibers and fans. A control knob with a clear scale makes it easy to adjust the setpoint. SPD900 is delivered with a 2m tube and 2 plastic duct connectors.

Medium: air and non-aggressive gases

Specifications	
SPD910	
Range	20-200 Pa
Maximum voltage rating	250Vac
Contacts	Silver
Current rating	0.1A resistive, 1A inductive
SPD910	
Range	40-600 Pa
Maximum voltage rating	250Vac
Contacts	Silver
Current rating	0.1A resistive, 2A inductive

Part number	Model number	Description
004701090	SPD910-2000Pa	Switch Pres Air SPD910-2000Pa
004701080	SPD910-1000Pa	Switch Pres Air SPD910-1000Pa
004701070	SPD910-500Pa	Switch Pres Air SPD910-500Pa
004701060	SPD910-300Pa	Switch Pres Air SPD910-300Pa

Appendix C

STX520

Immersion sensor, NTC 10 kohm for Continuum

STX520 is a temperature sensor intended for heating applications, measuring the water temperature mounted in a well.

The sensor element is an NTC 10 kohm for Continuum products.

The sensor, which is made of stainless steel, is delivered with a 2 or 4 m (6.5 or 13.1 ft.) cable PVC sheathed overall.

SPECIFICATIONS

Part number . . . . see table below
Sensor element . . NTC, 10 kohm at +25 °C (77 °F)

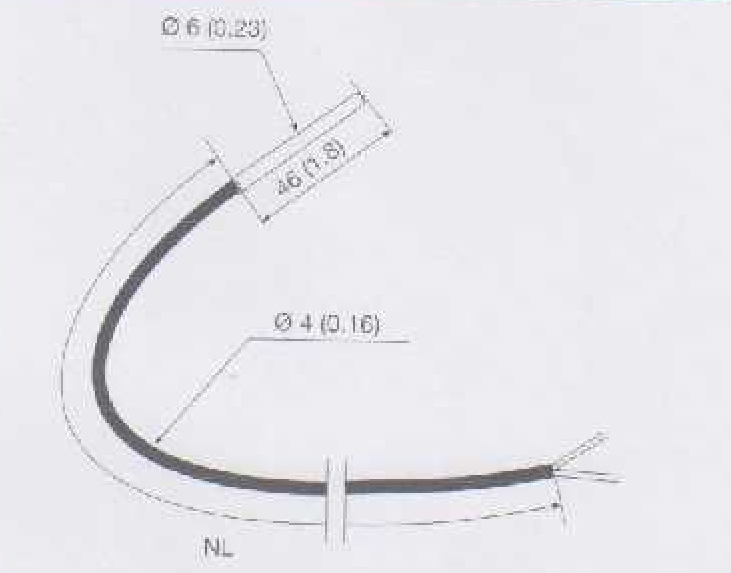
Operating temperature

Sensor . . . . −40 – +120 °C (−40 – +248 °F)
Cable . . . . −10 – +95 °C (+14 – +203 °F)
Time constant . . . . 6 s in stirred water
Accuracy . . . . please refer to table below
Enclosure rating . . . . IP 67
Ambient humidity . . . . max. 90% RH

Material

Sensor . . . . stainless steel, SUS 304 (SS 2332)
Cable . . . . PVC

DIMENSIONS mm (in)



ACCURACY

−25 °C/−13 °F . . . . ±0.5 °C/±0.9 °F
±0 °C/32 °F . . . . ±0.2 °C/±0.4 °F
25 °C/77 °F . . . . ±0.2 °C/±0.4 °F
50 °C/122 °F . . . . ±0.2 °C/±0.4 °F
70 °C/158 °F . . . . ±0.2 °C/±0.4 °F
100 °C/212 °F . . . . ±0.5 °C/±0.9 °F

SPECIFICATION REFERENCE

Part number	Product	NL		Weight	
		m	ft.	g	lb.
512-3320-000	STX520-200	2	6.5	80	0.18
512-3322-000	STX520-400	4	13.1	150	0.33

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03-00038-02-en

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