

CHAPTER ONE

INTRODUCTION

1.1 Overview

Large centralized building computerized control systems first appeared in the 1960s. These evolved from industrial process control systems into mini-computer-controlled systems deployed in the late 1960s. Initially, they appeared in only the largest new buildings where the first cost of the system could be broadly amortized and reductions realized in buildings operation and maintenance staff.

Energy became a significant concern in the early- and mid-1970s as a result of the oil embargoes. Energy cost pressures increased the market share of EMCSs. In addition, the functionality of EMCSs expanded, incorporating energy-saving features such as separate day and night schedules for HVAC and lighting, and demand control.

1.2 Research Problems

Due to high energy, consumed and high cost of equipment's and tools of ventilation, air conditioning and safe security for buildings will any risk of humans and equipment's.

1.3 Research Objectives

To study the main components of the BMS that include HVAC, Fire Alarm and security system.

To simulate the system using controllers, heat, smoke, temperature and Light Dependent Resistor (LDR) detectors.

1.4 Research Methodology

Visit has been carried out to recognize the BMS systems. The ALSAHEL–SAHRAA Bank is a bank using a BMS system converting the firefighting system, closed circuit television (CCTV), HVAC, uninterruptible power supply and security systems.

The system has been simulated by Proteus.

1.5 Research Outlines

This research consists of four Chapters including Chapter One. Chapter Two concern with an explanation of the subsystem of the BMS and fire alarm system .Chapter Three consists of an overview of heating, ventilation and air conditioning. Chapter Four presents an overview of the main components of the project, Chapter Five gives a brief conclusion and summary to the project.

CHAPTER TWO

BUILDING MANAGEMENT SYSTEM

FUNDAMENTALS

2.1 Introduction

The BMS concept emerged in the early 1950s and has since changed dramatically both in scope and system configuration. System communications evolved from hardwired (and home-run piping for pneumatic centralization) to multiplexed (shared wiring) to today's two-wire all digital system. The Energy Management System and Building Management and Control System evolved from poll-response protocols with central control processors to peer-to-peer protocols with distributed control[1].

Energy management is typically a function of the microprocessor-based Direct Digital Control controller. In most mid-sized to large buildings, energy management is an integral part of the Building Management and Control System, with optimized control performed at the system level and with management information and user access provided by the BMS host [1].

Equipment is operated at a minimum cost and temperatures are controlled for maximum efficiency within user-defined comfort boundaries by a network of controllers. Energy strategies are global and network communications are essential [1].

Load leveling and demand control along with starting and loading of central plant based upon the demands of air handling systems require continuous global system coordination [1].

Energy Management BMS host functions include the following:

- Efficiency monitoring – recording
- Energy usage monitoring – recording
- Energy summaries
- Energy usage by source and by time period
- On-times, temperatures, efficiencies by system, building, area
- Access to energy management strategies for continuous tuning and adapting to changing needs
- Occupancy schedules

Energy Management for buildings preceded Direct Digital Control by about ten years. These pre- Direct Digital Control systems were usually a digital architecture consisting of a central computer which contained the monitoring and control strategies and remote data gathering panels (DGPs) which interfaced with local pneumatic, electric, and electronic control systems. The central computer issued optimized start/stop commands and adjusted local loop temperature controllers [1].

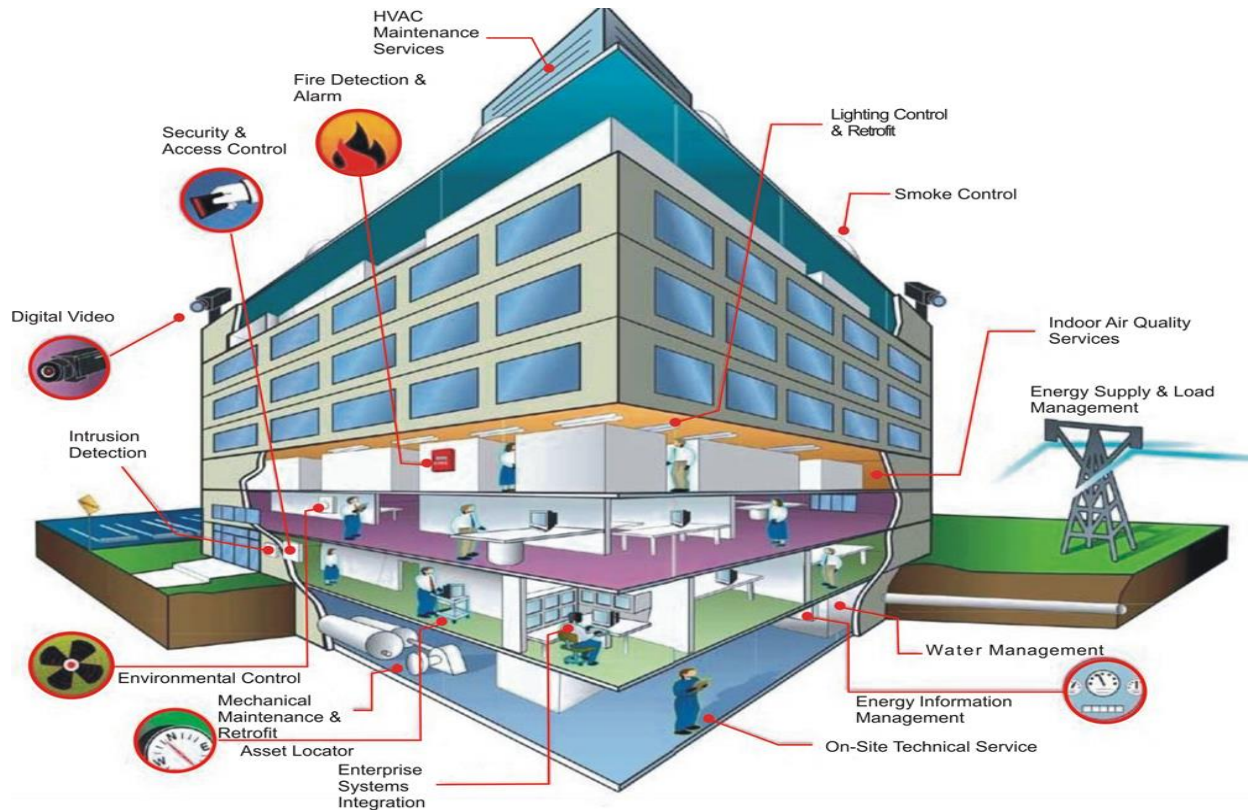


Figure (2.1) BMS prototype

2.2 System Configurations

A BMS includes the hardware configuration and communication systems needed to access data throughout a building or from remote buildings using leased telephone lines [1].

2.2.1 Hardware Configuration

Microprocessor-based controllers have led to a hierarchical configuration in the BMS. Figure (2.4) shows several levels, or tiers, of processors.

- Management-level processors
- Operations-level processors
- System-level controllers
- Zone-level controllers

The actual levels used in a given system depend on the specific needs of the building or complex of buildings. The zone level may incorporate intelligent, microprocessor-based sensors and actuators [1].

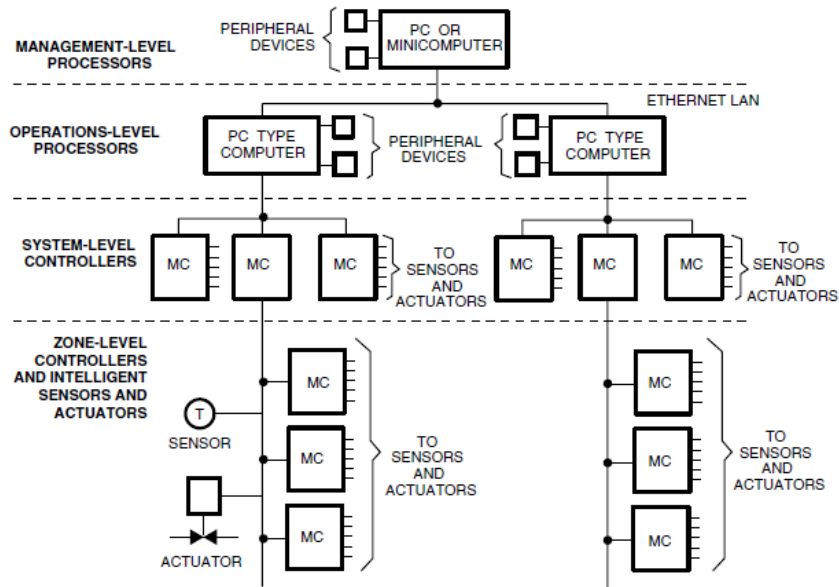


Figure (2.2) hardware configuration

2.2.2 Zone-level controllers

Zone-level controllers are microprocessor-based controllers that provide direct digital control of zone-level equipment, including items such as VAV boxes, heat pumps, single zone air handlers, and perimeter radiation. Energy management software can also be resident in the zone-level controller. At the zone level, sensors and actuators interface directly with the controlled equipment. A communications bus provides networking of zone-level controllers so that point information can be shared between zone-level controllers and with processors at the system and operation level. Zone-level controllers typically have a port or communications channel for use of a portable terminal during initial setup and subsequent adjustments [1].

2.2.3 System-level controllers

Microprocessor-based system-level controllers have greater capacity than zone-level controllers in terms of number of points, Direct Digital Control loops, and control programs. System-level controllers are usually applied to major pieces of mechanical equipment such as large built-up air handlers, central Variable Air Volume systems, and central chiller plants. These controllers can also perform lighting control functions. Controllers at this level interface with controlled equipment directly through sensors and actuators or indirectly through communications links with zone-level controllers. System-level controllers typically have a port for connecting portable operating and programming terminals during initial setup and subsequent adjustments.

When system-level controllers are linked to operations-level processors, subsequent changes to controller programs are normally made at the operations-level processor and then downline loaded to the controller using the system transmission lines [1].

System-level controllers also provide system survivability by operating in a stand-alone mode should its communication link be lost. Some types of system-level controllers also provide the property and life-safety protection for the facility through fire alarm panels, security panels, and access control panels [1].

2.2.4 Operations-level processors

Operations-level processors interface primarily with Building Management and Control System operating personnel. The processor at this level is in most cases a PC with color operator terminal displays and plug-in function boards to accommodate additional operator terminals, printers, memory expansion, and communications links. An operations level processor generally includes application software for:

- System security: Limits access and operation to authorized personnel.
- System penetration: Permits authorized personnel to select and retrieve system data via PC keyboard or other selection mechanism.
- Custom programming: Develops custom Direct Digital Control programs at the operations level for down-line loading to specific, remote system-level controllers and zone-level controllers.
- Graphics: Builds custom graphic displays incorporating dynamic system data. Bar chart and curve plot software may be included.
- Standard reports: Provides automatic, scheduled, and by request reports of alarm and operator activity. Also provides a broad range of system, category and summary reports.
- Custom reports: Provides spread sheet, word processing, and a data base management capability.
- Maintenance management: Automatically schedules and generates work orders for equipment maintenance based either on history of equipment run time or on a calendar schedule.
- Site-specific customization: Allows defining operator assignments, peripheral device assignments, printer data segregation, system configuration, and display and printout text of action message assignments to specific points, time/holiday scheduling, point monitoring/control, time / event program assignments, and application program parameter assignments.
- System integration: Provides common control and interface for multiple subsystems (Heating Ventilation and Air Conditioning, fire, security, access control) and provides global activity as a result of specific subsystem events [1].

2.2.5 Management-level processors

Management-level processors, at the top of the BMCS system hierarchy, exercise control and management over the connected subsystems. An operator at this level can request data from and issue commands to points anywhere in the system (as with most operations-level processors). Day-to-day operation is normally a function of the operations-level processor; however, complete control can be transferred to the management-level processor during emergencies or unattended periods. The management-level processor primarily collects, stores, and processes historical data such as energy use, operating costs, and alarm activity, and generates reports that provide a tool for the long-term management and use of the facility [1].

2.3 Communications Protocol

Bus equally among all bus devices with no master device. Communications protocol is an essential element of the BMCS configuration due to the amount of data transferred from one point to another and because distributed processors may be dependent on each other for data pertinent to resident programs. Communications links, or buses, generally use either a poll/response or a peer protocol. Early BMCSs use poll/response protocols where most system intelligence and data processing was at the central processor. In the mid-1990s most BMCSs use peer protocols which share the communications bus equally among all bus devices with no master device [1].

2.3.1 Peer communications protocol

Peer communications protocol has the following advantages over poll/response communications protocol:

- Communication not dependent on a single device as the master.

- Direct communication between bus-connected devices without going through the BMS central processor.
- Global messages transmitted to all bus-connected devices.

In peer communications a time slot is automatically passed from one bus-connected device to another as the means of designating when a device has access to the bus. Since the time slot passes in an orderly sequence from one device to the next, the communications network is sometimes termed a ring.

However, the bus is not necessarily physically looped nor are the devices physically connected to form a ring. Any device on the bus can be designated as the first to receive the time slot, and any other device the next to receive it, and so on [1].

2.3.2 Communications Media

The most common choices for BMS transmission trunks are:

- Twisted copper pair
- Fiber optic cable
- Common carrier telephone channels

The media best suited for a given installation depends on the signal, cost, geographic layout, and the possibility of line interference [1].

2.4 System Functions

Each Building Management and Control System level provides some degree of stand-alone capability and collects and preprocesses data for other processing levels. The following discussion starts with the functions provided by the lowest level of processing in the configuration, or hierarchy, and progresses to the highest level [1].

- **Zone-level controller functions**

The primary function of the zone-level controller is to provide direct digital control of unitary equipment. To support the resident Direct Digital Control programs, the zone-level controller interfaces with sensors and actuators and performs the functions of point processing as well as execution of the Direct Digital Control programs [1].

- **System-level controller functions**

System-level controllers provide increased processing capability, higher I/O capacity, and more universal application flexibility than zone-level controllers and have greater standalone capability. System-level controllers handle multiple Direct Digital Control loops and the complex control sequences associated with built-up air handling units and other Heating Ventilation and Air Conditioning equipment. Other types of system-level controllers monitor multiple zones of fire alarm, security points, and/or lighting control. They can also provide emergency evacuation control through speakers and control personnel movement with access control and card readers. For a detailed description of system-level controllers, refer to Microprocessor-Based/ Direct Digital Control Fundamentals section.

Processed point data at the system controller level is used directly by the resident Direct Digital Control, Energy Management System, and time/event programs.

The data is also available for readout at local control panels, portable terminals, and can be communicated up to the operations-level processor and to other system-level controllers. In addition, all parameters and output value associated with Direct Digital Control and other resident programs are accessible for local and operations-level readout and adjustment. Data point values may be shared between zone level controllers, between system-level controllers, and between zone- and system-level controllers [1].

- **Operations-level functions**

The operations level is the third tier of the configuration. Building or facility operations and management personnel interact on a day-to-day basis through this level. The hardware and software for this tier is dedicated to interfacing with operating personnel rather than with mechanical systems, as the controllers do in the lower tiers of the Building Management and Control System configuration [1].

- **Server**

When using multiple operation/management-level processors, one is defined as the database server, where all current database resides. Any processor may initiate a system change (graphic or text modification, operator assignment, schedule, etc.), but all changes are made to the server database [1].

The server is a software function and may be a dedicated PC or any other LAN processor.

All LAN processors operate from the server, which periodically updates the databases of the other LAN processors. When the server (LAN) is down, the processors operate from their own database [1].

- **Security**

System security software prevents unauthorized system access and can limit authorized personnel to geographic areas as well as function (acknowledge alarms, issue commands, modify database, etc.). Top level operators assign security passwords and enter security parameters for other operators.

If no keyboard or mouse activity occurs for a predetermined time period, the operator is automatically signed-off. All operator sign-on and sign-off activity is archived [1].

- **Alarm Processing**

Upon receiving an alarm from a controller, operations-level processors initiate alarm processing as follows:

- Time/Date.
- Text action message.
- Present acknowledge button.
- Initiate audible.
- No audible.
- For timed duration or continuously.
- Fast, medium or slow beep rate.
- (Option) Automation Graphic Display.
- Present button for operator graphic display request.

Present alarm status on graphics (point red if in alarm, blinking if unacknowledged)

The alarm archive may be queried at any time to analyze historical alarm activity [1].

- **Reports**

BMS Software includes many system reports for display and printout in addition to alarm reports.

Database reports document system software such as point processing parameters, system text, controller configuration, etc. The trend report utility allows for archival of data point status and values for subsequent review. Archival may be based upon a time interval or a change in status or value. Trend data may be reviewed as archived or may be sorted and reduced, such as “Print the maximum daily temperature from 3-16-96 to 5-16-96”. Trend data may be presented in columnar format or as a curve plot with up to eight points per display/printout.

Trend sample requirements are usually set-up in the controller and automatically reported to the BMS thereafter.

Other standard reports may be:

- All point summary.
- Alarm summary.
- Disabled Points Log.
- Single System Summary (single Air Handling Unit or single chiller).

Controller Status Summary [1].

- **System Text**

BMS system text includes unique names for all controllers, PCs, peripherals, and active communications devices. Each building, Heating Ventilation and Air Conditioning system, and hardware and software point also has a unique name. Each alarm point includes an alarm message such as “call maintenance” and may have an extended unique alarm instruction of up to 480 characters. Extended messages typically tell a BMS operator what to do, what not to do, what to investigate, who to call, which forms to fill out, what to order, etc. Unique system text may be in any language which uses ASCII Characters [1].

2.5 Fire alarm system

A system or portion of a combination system that consists of components and circuits arranged to monitor and annunciate the status of fire alarm or supervisory signal-initiating devices and to initiate the appropriate response to those signals.

All Fire Alarm Systems essentially operate on the same principle. If a detector detects smoke or heat, or someone operates a break glass unit, then alarm sounders operate to warn others in the building that there may be a fire and to evacuate. For the system protecting property, it is additionally likely that the Fire Alarm will incorporate remote signaling equipment which would alert the fire brigade via a central station [2].

Wired Fire Alarm Systems can be broken down into three categories, Conventional, Addressable and Analogue Addressable.

- **Conventional fire alarm system**

Figure (2.2) In a Conventional Fire Alarm System, a number of call points or a number of call points and detectors are wired to the Fire Alarm Control Panel in Zones. A Zone is a circuit and typically one would wire a circuit per floor or fire compartment. The Fire Alarm Control Panel would have a number of Zone Lamps. The reason for having Zones is to give a rough idea as to where a fire has occurred. The accuracy of knowing where a fire has started is controlled by the number of Zones a Control Panel has, and consequently, the number of circuits that have been wired within the building. The Control Panel would then be wired to a minimum of two sounder circuits which could contain bells, electronic sounders or other audible devices. Sounder Circuits and Detection Zones are wired in a star configuration. Each circuit would have an end of line device which is used for monitoring purposes. Controls currently use resistors for use on the end of all sounder circuits and for use on the end of the Detection Circuits for all of their Conventional Control Panels [2].

CONVENTIONAL FIRE ALARM SYSTEMS

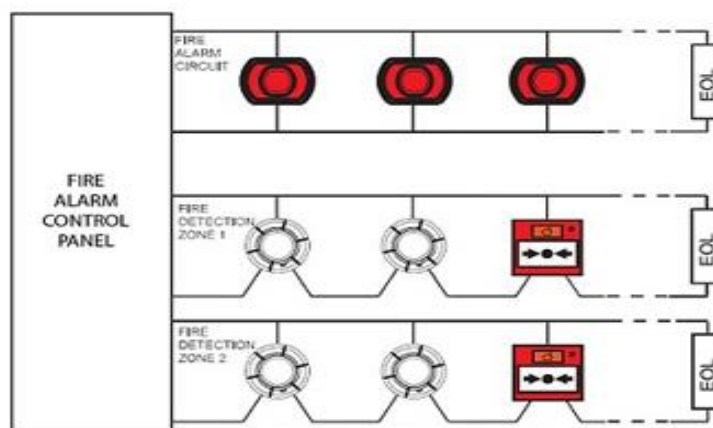


Figure (2.3) conventional system

- **Addressable Systems**

The detection principle of an Addressable System is similar to a Conventional System except that the Control Panel can determine exactly which detector or call point has initiated the alarm.

Figure (2.3) show the detection circuit is wired as a loop and up to 99 devices may be connected to each loop. The detectors are essentially Conventional Detectors, with an address built in. The address in each detector, is set by dill switches and the Control Panel is programmed to display the information required when that particular detector is operated. Additional Field Devices are available which may be wired to the loop for detection only ie: it is possible to detect a normally open contact closing such as sprinkler flow switch, or a normally closed contact opening.

Sounders are wired in a minimum of two sounder circuits exactly as a Conventional System.

Loop Isolation Modules are available for fitting on to the detection loop/loops such that the loop is a sectioned in order to ensure that a short circuit, or one fault will only cause the loss of a minimal part of the system [2].

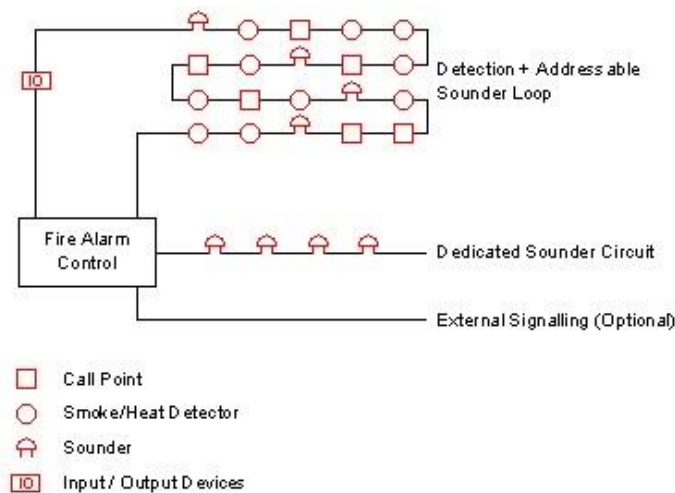


Figure (2.4) Addressable System

- **Analogue fire alarm systems**

Analogue Fire Alarm Systems are often known as Intelligent Fire Alarm Systems.

There are several different types of Analogue Systems available which are determined by the type of protocol which they use. The bulk of Analogue Detectors available are a fairly stupid as the Detectors can only give output signals representing the value of sensed phenomena. It is left up to the Control Unit to decide whether there is a fire, fault, pre alarm or whatever. With the Protein True Intelligent Analogue System each detector effectively incorporates its own computer which evaluates the environment around it, and communicates to the Control Panel whether there is a fire, fault or the detector head needs cleaning.

Essentially however, Analogue Systems are far more complex and incorporate far more facilities than Conventional or Addressable Systems. Their primary purpose is to help prevent the occurrence of false alarms. With the Analogue Addressable System up to 127 input devices i.e.: Smoke Detectors, Call Points, Heat Detectors, Contact Monitors and other interface devices may be wired to each detection loop. In addition to the 127 Input Devices, up to 32 Output Devices such as Loop Sounders, Relay Modules and Sounder Modules may also be connected Analogue Systems are available in 2,4 and 8 loop versions which means large premises can be monitored from one single panel. Isolator units should be connected between a sections of detectors as described for Addressable Systems [2].

CHAPTER THREE

Heating Ventilation and Air Conditioning

3.1 Introduction

Heating, ventilation and air conditioning (HVAC), is the technology of indoor and vehicular environmental comfort. Its goal is to provide thermal comfort and acceptable indoor air quality. HVAC system design is a sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. HVAC is an important part of residential structures such as single family homes, apartment buildings, hotels and senior living facilities, medium to large industrial and office buildings such as skyscrapers and hospitals, onboard vessels, and in marine environments, where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors.

Ventilating or ventilation (the V in HVAC) is the process of exchanging or replacing air in any space to provide high indoor air quality which involves temperature control, oxygen replenishment, and removal of moisture, odors, smoke, heat, dust, airborne bacteria, carbon dioxide, and other gases. Ventilation removes unpleasant smells and excessive moisture, introduces outside air, keeps interior building air circulating, and prevents stagnation of the interior air.

Ventilation includes both the exchange of air to the outside as well as circulation of air within the building. It is one of the most important factors for maintaining

acceptable indoor air quality in buildings. Methods for ventilating a building may be divided into mechanical/forced and natural types [3].

3.2 Air Conditioning

The majority of the air is drawn from the space, mixed with outside ventilation air and then conditioned before being blown back into the space as shown in Figure (3.1).

Air-conditioning systems are designed to meet a variety of objectives. In many commercial and institutional systems, the ratio of outside ventilation air to return air typically varies from 15 to 25% of outside air. There are, however, systems which provide 100% outside air with zero recirculation. The components are:

Outside Air Damper, which closes off the outside air intake when the system is switched off. The damper can be on a spring return with a motor to drive it open; then it will automatically close on power failure. On many systems there will be a metal mesh screen located upstream of the filter, to prevent birds and small animals from entering, and to catch larger items such as leaves and pieces of paper.

Mixing chamber, where return air from the space is mixed with the outside ventilation air.

Filter, which cleans the air by removing solid airborne contaminants (dirt). The filter is positioned so that it cleans the return air and the ventilation air. The filter is also positioned upstream of any heating or cooling coils, to keep the coils clean. This is particularly important for the cooling coil, because the coil is wet with condensation when it is cooling.

Heating coil, which raises the air temperature to the required supply temperature.

Cooling coil, which provides cooling and dehumidification. A thermostat mounted in the space will normally control this coil. A single thermostat and controller are often used to control both the heating and cooling coil. This method reduces

energy waste, because it ensures the two coils cannot both be “on” at the same time.

Humidifier, which adds moisture, and which is usually controlled by a Humidistat in the space. In addition, a high humidity override humidistat will often be mounted just downstream of the fan, to switch the humidification “off” if it is too humid in the duct. This minimizes the possibility of condensation forming in the duct.

Fan, to draw the air through the resistance of the system and blow it into the space.

Heating: directly by the space thermostat controlling the amount of heat

Supplied by the heating coil. Cooling: directly by the space thermostat controlling the amount of cooling supplied to the cooling coil.

Dehumidifying: by default, when cooling is required, since, as the cooling coil cools the air, some moisture condenses out.

Ventilating: provided by the outside air brought in to the system.

Cleaning: provided by the supply of filtered air.

Air movement within the space is not addressed by the air-conditioning plant, but rather by the way the air is delivered into the space[4].

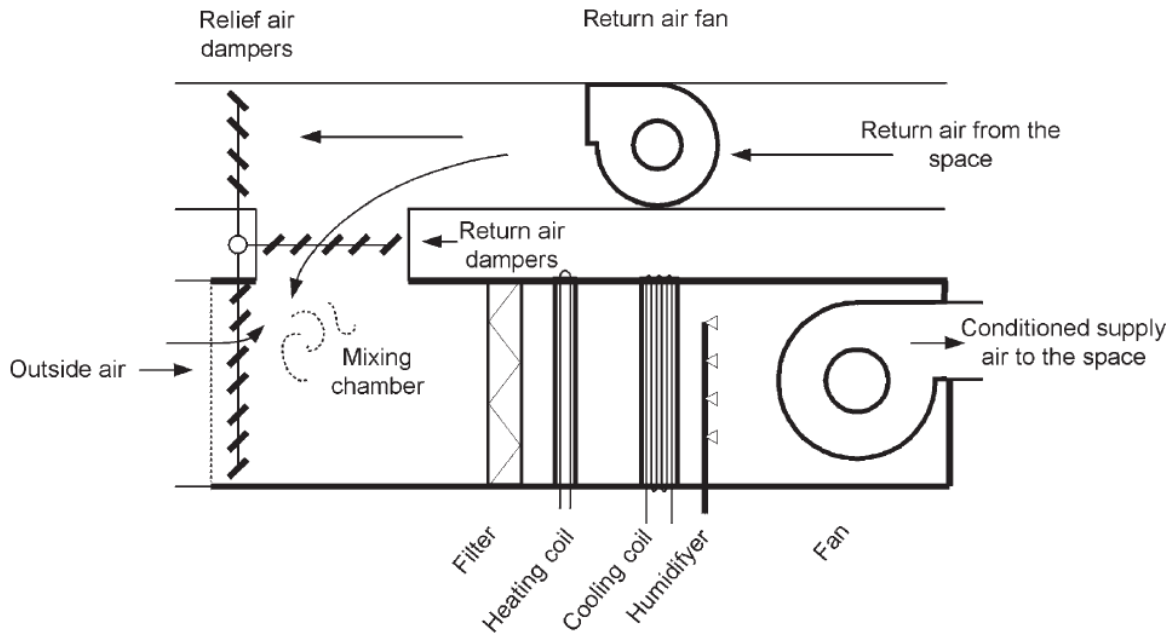


Figure (3.1) Air-Conditioning

3.2.1 Zoned Air-Conditioning Systems

The air-conditioning system considered so far provides a single source of air with uniform temperature to the entire space, controlled by one space thermostat and one space humidistat. However, in many buildings there is a variety of spaces with different users and varying thermal loads. These varying loads may be due to different inside uses of the spaces, or due to changes in cooling loads because the sun shines into some spaces and not others. Thus our simple system, which supplies a single source of heating or cooling, must be modified to provide independent, variable cooling or heating to each space. When a system is designed to provide independent control in different spaces, each space is called a “**zone**.” A zone may be a separate room. A zone may also be part of a large space. For example, a theatre stage may be a zone, while the audience seating area is a second zone in the same big space. Each has a different requirement for heating and cooling. This need for zoning leads us to the four broad categories of air-

conditioning systems, and consideration of how each can provide zoned cooling and heating. The four systems are:

1. All-air systems
2. Air-and-water systems
3. All-water systems
4. Unitary, refrigeration-based systems [4].

3.2.2 Variable air volume (VAV) system

It varies the volume of air supplied to each zone. Variable Air Volume systems are more energy efficient than the reheat systems. Again, assume that the basic system provides air that is cool enough to satisfy all possible cooling loads. In zones that require only cooling, the duct to each zone can be fitted with a control damper that can be throttled to reduce the airflow to maintain the desired temperature. In both types of systems, all the air-conditioning processes are achieved through the flow of air from a central unit into each zone. Therefore, they are called “**all-air systems**” As in Figure (3.2) [4].

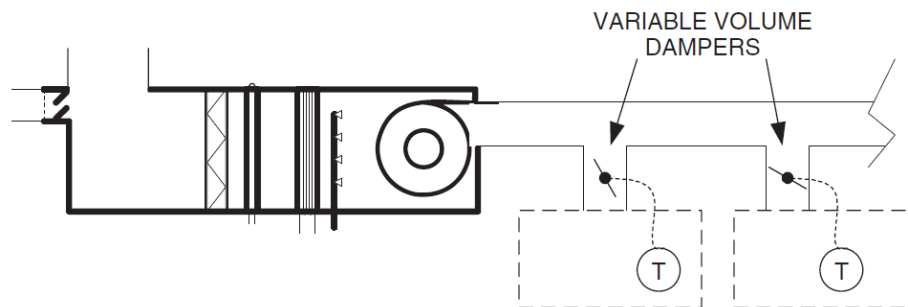


Figure (3.2) Variable Air Volume

3.2.3 Choosing an air-Conditioning system

The factors, or parameters that influence system choice can conveniently be Divided into the following groups:

- **Building Design**

The design of the building has a major influence on system choice. For example, if there is very little space for running ducts around the building, an all-air System may not fit in the available space.

- **Location Issues**

The building location determines the weather conditions that will affect the Building and its occupants. For the specific location that will need to consider factors like Site conditions, peak summer cooling conditions, summer humidity, Peak winter, heating conditions, Wind speeds, Sunshine hours, and typical snow accumulation depths.

- **Utilities: Availability and Cost**

The choice of system can be heavily influenced by available utilities and their costs to supply and use. So, if chilled water is available from the adjacent building, it would probably be cost advantageous to use it, rather than install new unitary refrigerant-based units in the new building.

- **Indoor Requirements and Loads**

The location effects and indoor requirements provide all the necessary information for load calculation for the systems.

- **The thermal and moisture loads:** Occupants' requirements and heat output from lighting and equipment affect the demands on the air-conditioning system.
- **Outside ventilation air:** The occupants and other polluting sources, such as cooking, will determine the requirements.
- **Zoning:** The indoor arrangement of spaces and uses will determine if, and how, the system is to be zoned [4].

3.3 Ventilation and indoor air quality

Filtration Figure (3.4), is the removal of contaminants from the air. Both particulate (particles of all sizes) and gaseous contaminants can be removed, but since gaseous filtration is a rather specialized subject, it is not content on this project. Particulate filters work by having the particles trapped by, or adhere to, the filter medium. The actual performance of a filter depends on several factors, including particle size, air velocity through the filter medium, filter material and density, and dirt buildup on the filter. The main operating characteristics used to distinguish between filters are: Efficiency in removing dust particles of varying sizes Resistance to airflow Dust holding capacity (weight per filter) Choosing a filter is a matter of balancing requirements against initial purchase cost, operating cost and effectiveness. In general, both the initial cost and the operating cost of the filter will be affected by the size of the particles that need to be filtered out, and the required efficiency of the filter: the smaller the particle size and the greater the efficiency required, the more expensive the filter costs as in Figure (3.3) [4].

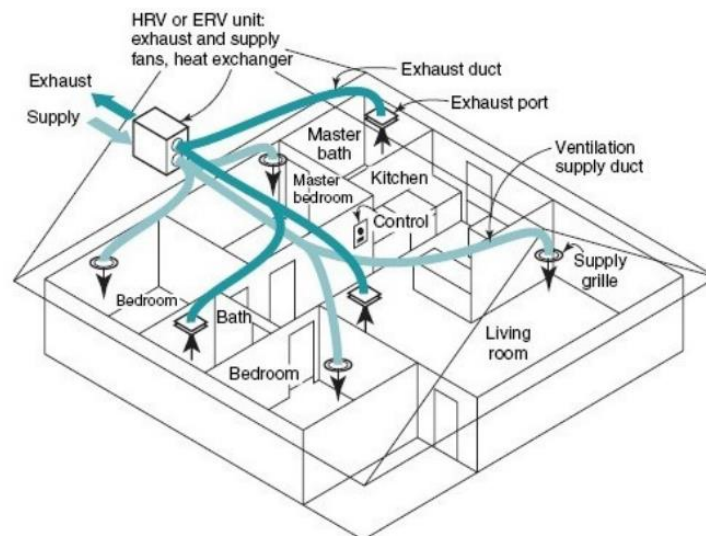


Figure (3.3) Ventilation

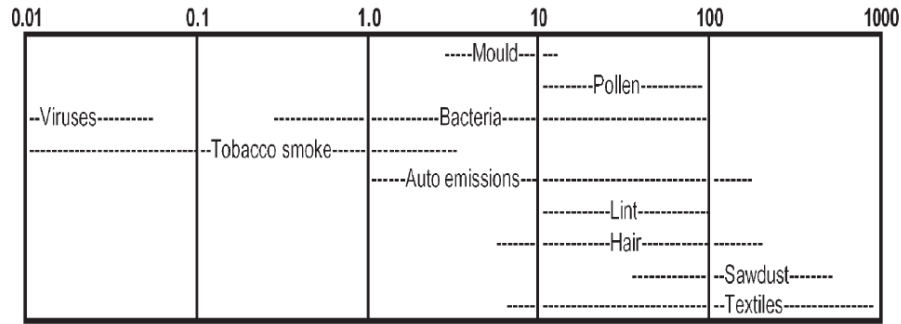


Figure (3.4) Filtration

3.4 Chiller system control

Chilled water systems are used in many buildings for cooling because of their flexibility and operating cost compared with direct expansion (DX) cooling coil systems. Typically, chilled water is generated at a central location by one or more chillers and distributed to coils in air handling system Figure (3.5). The quantity and temperature of the water supplied must be sufficient to meet the needs of all fan systems. Since the chilled water system is the major user of energy in many buildings, energy costs should be a consideration in chilled water plant configuration.

A chilled water system can provide hot water for a heating load when a simultaneous heating and cooling load exists. It can be used with a chilled water, ice tank, or phase change material thermal storage system to lower the peak load demand and allow use of a smaller chiller. It can use the system cooling tower during light load conditions to supply cool water to the system without running the chiller, if the outside air temperature is low enough. Chiller capacity controls are usually factory installed by the chiller manufacturer. The BMCS usually stages chillers on and off, provides chiller controls with a chilled water temperature set point, and controls the condenser water system. Chillers are usually controlled from their leaving water temperature; except that chillers using reciprocating

compressors are often controlled from their entering water temperature, since staging and loading in steps causes steps in the leaving water temperature [1].

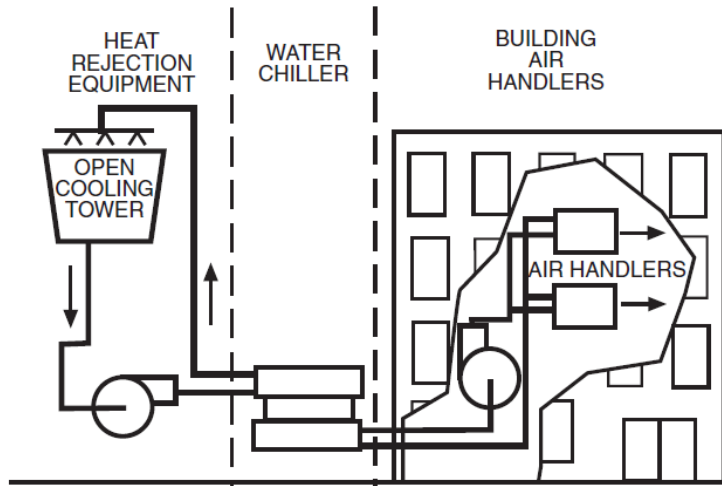


Figure (3.5)Chiller system control

3.4.1 Chiller Types

Chiller types are classified by type of refrigeration cycle: vapor compression or absorption, those using the vapor compression cycle are referred to by the type of compressor: centrifugal or positive displacement. A positive displacement compressor can be either reciprocating or screw for this discussion [1].

3.4.2 Vapor-compression refrigeration

The vapor-compression cycle is the most common type of refrigeration system. When the compressor (Figure 3.6) Starts, the increased pressure on the high side and the decreased pressure on the low side causes liquid refrigerant to flow from the receiver to the expansion valve. The expansion valve is a restriction in the liquid line which meters the refrigerant into the evaporator. It establishes a boundary between the low (pressure) side, including the evaporator and the high (pressure) side, including the condenser and the receiver. The compressor is the

other boundary. The liquid refrigerant in the evaporator boils as it absorbs heat from the chilled water. The refrigerant leaves the evaporator and enters the compressor as a cold low-pressure gas. The refrigerant leaves the compressor as a hot high-pressure gas and passes through the condenser where it is cooled by the condenser water until it condenses and returns to the receiver as a liquid. The cycle is the same regardless of the compressor type or refrigerant used [1].

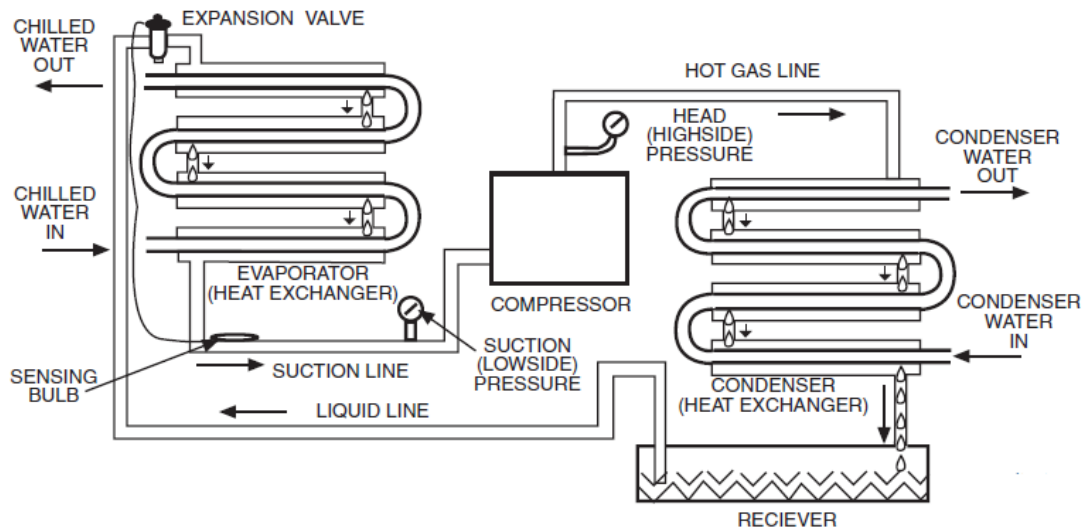


Figure (3.6)vapor-compression refrigeration

3.4.3 Absorption Refrigeration

The absorption cycle uses a fluid called an absorbent to absorb evaporated refrigerant vapor in an “absorber” section. The resulting combination of fluid and refrigerant is moved into a “generator” section where heat is used to evaporate the refrigerant from the absorbent.

In the absorber (Figure 3.7) the absorbent, also called strong absorbent at this point, assimilates the refrigerant vapor when sprayed through it. The resulting weak absorbent is pumped by the generator pump through the heat exchanger, where it picks up some of the heat of the strong absorbent, then into the generator.

In the generator the weak absorbent is heated to drive (evaporate) the refrigerant out of the absorbent and restore the strong absorbent. The strong absorbent then passes through the heat exchanger, where it gives up some heat to the weak absorbent, and then returns to the spray heads in the absorber completing the cycle for the absorbent ^[5].

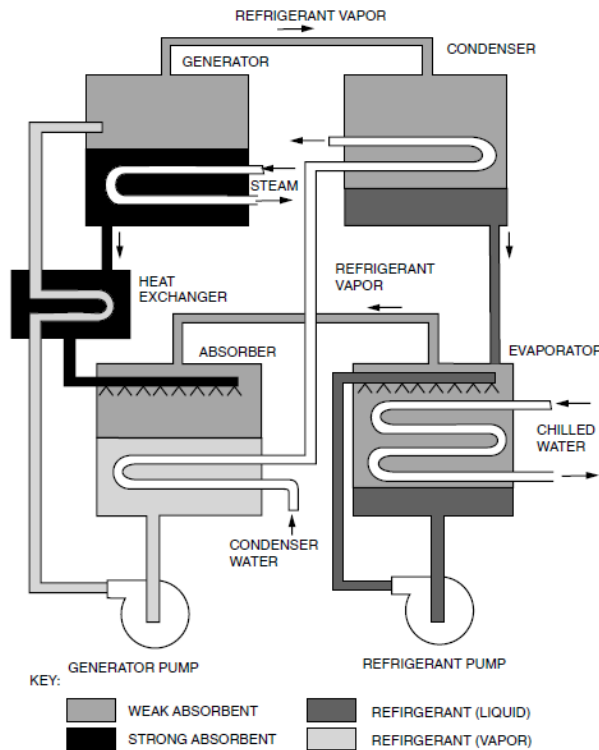


Figure (3.7) Absorption Refrigeration

3.5 Chiller control requirements

Basic chiller control is a sensor in the chilled water supply or return and a controller to provide a control signal to a capacity control actuator. Capacity control is unique to each compressor type. Summarized, the controls for each compressor type are:

1. Centrifugal Controller output operates a pneumatic or electric actuator to position inlet vanes as a function of the controlled temperature. If speed control is available, the controller sequences motor or rotor speed with inlet vanes.

2. Reciprocating Controller provides a stepped output to sequence refrigerant solenoid valves, valve unloading, hot gas bypass, or multiple compressors as a function of controlled temperature.
3. Screw Controller operates speed control or a pneumatic or electric actuator to position sliding bypass valve in response to temperature input.
4. Absorption–Controller output operates a valve to modulate the steam, hot water, or gas supply to maintain controlled temperature [5].

3.6 Chilled water systems

The central cooling system generates chilled water for distribution to a building or group of buildings. It consists of one or more chillers. Multiple chillers may all be the same or different capacities and/or different types. The energy may be provided by electricity or a fuel-combustion source. Central chiller system optimization is an important control function to minimize energy use, especially in multiple chiller plants. The control program must be dynamic and constantly check current conditions and adjust chiller system operations accordingly. A control program must select the most efficient loading and chiller combinations then, sequence pumps and control cooling towers to match the current load condition. Built-in safeguards prevent short cycling and exceeding demand limits.

Strategies for total chiller system optimization include:

1. Supplying chilled water at a temperature that minimizes chiller and pump energy while satisfying the current demand load.
2. Selecting the chiller or chiller combination in multiple chiller plants to satisfy the current load at minimum operating cost. The influence of refrigerant head pressures and chiller efficiency curves must be considered.
3. Using rejected heat when a heating load exists at the same time as a cooling load.

4. Using thermal storage to store day time rejected heat and/or night time cooling. Thermal storage can also reduce the size of chiller equipment [1].

3.7 System description

The main concept of the designed block diagram as shown in Figure (4.1) describe the inputs and outputs components Then receive factors from sensors and switches in order to activate the outputs such as conditioning units, LEDs, Relays, Lights, Buzzers, Pumps and LCDs.

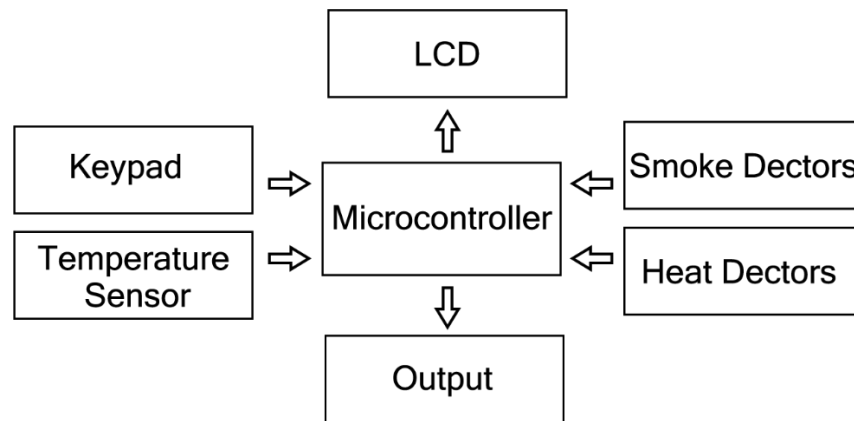


Figure (3.8) block diagram of building management system

The system components selected according to the functionality of building management system, microcontroller PIC is required to control the building management system actuators according to certain values received from sensors in order to activate other components.

3.7.1 Pic 16F877A microcontroller

The PIC16F877A microcontroller as shown in Figure (4.2) is one of the latest products from Microchip. It features all the components which modern microcontrollers normally have. For its low price, wide range of application, high quality and easy availability, it is an ideal solution in applications such as the

control of different processes in industry, machine control devices, measurement of different values etc. Some of its main features are listed below. The selection has been done due to their Small instruction set to learn, Inexpensive microcontrollers; built in oscillator with selectable speeds, Wide range of interfaces.

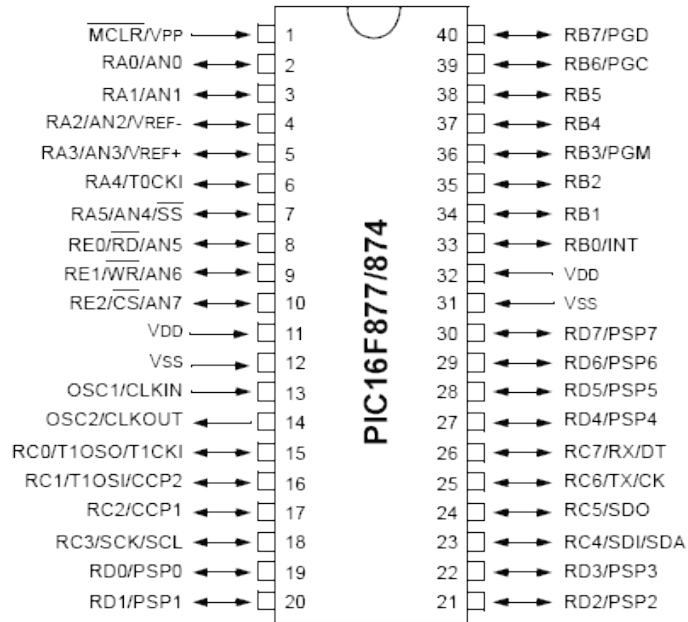


Figure (3.9) pic16F877A, Top view

3.7.2 Light dependent resistor LDR

A light dependent resistor as shown in Figure (3.10) also known as a LDR is photo-resistor, photoconductor or photocell, is a resistor whose resistance increases or decreases depending on the amount of light intensity. LDRs (Light Dependent Resistors) are a very useful tool in a light/dark circuits. A LDR can have a variety of resistance and functions. For example it can be used to turn on a light when the LDR is in darkness or to turn off a light when the LDR is in light. It can also work the other way around so when the LDR is in light it turns on the circuit and when it's in darkness the resistance increase and disrupts the circuit.

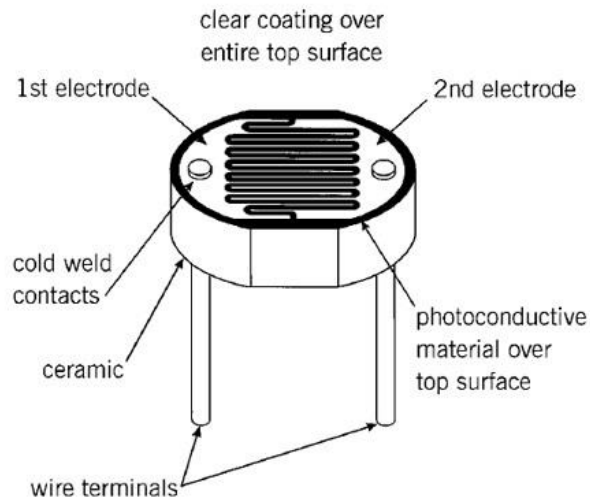


Figure (3.10) LDR Construction

3.7.3 Temperature sensor LM35

The LM35 as shown in Figure (3.11) are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

The LM35 does not require any external calibration or trimming to provide typical accuracies of $\pm 1/4^{\circ}\text{C}$ at room temperature and $\pm 3/4^{\circ}\text{C}$ over a full -55 to $+150^{\circ}\text{C}$ temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only $60\ \mu\text{A}$ from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a -55° to $+150^{\circ}\text{C}$ temperature range, while the LM35C is rated for a -40° to $+110^{\circ}\text{C}$ range (-10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92

transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

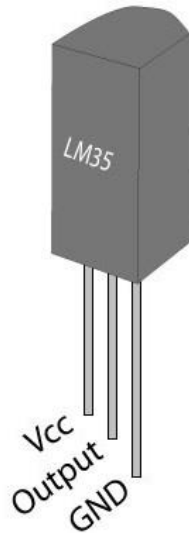


Figure (3.11) Temperature sensor LM35

3.7.4 LCD display

A liquid-crystal display (LCD) shown in Figure (3.12) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, They come in many sizes 8x1 , 8x2 , 10x2 , 16x1 , 16x2 , 16x4 , 20x2 , 20x4 ,24x2 , 30x2 , 32x2 , 40x2 etc. Many multinational companies like Philips Hitachi Panasonic make their own special kind of LCD's to be used in their products. All the LCD's performs the same functions (display characters numbers special characters ASCII characters etc.). Their programming is also same and they all have same 14 pins (0-13) or 16 pins (0 to 15) as shown in Figure (3.12).

All LCDs have:

- 8 Data pins.
- VCC (Apply 5v here).
- GND (Ground this pin).
- RS (Register select).
- RW (read - write).
- EN (Enable).
- V0 (Set LCD contrast)

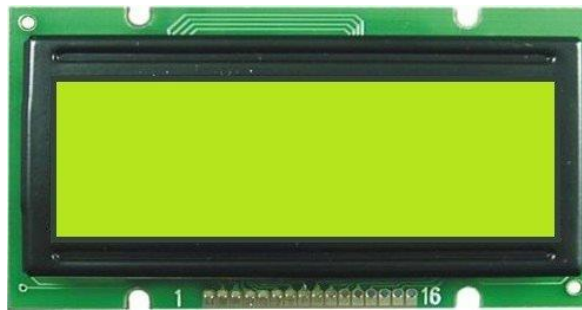


Figure (3.12) LCD Display

3.7.5 Keypad 4x4

A 16-button keypad as shown in Figure (3.13) provides a useful human interface component for the most applications in daily life. Convenient adhesive backing provides a simple way to mount the keypad in a variety of applications.



Figure (3.13) Keypad 4x4

3.7.6 Resistors

Resistors (R) are the most fundamental and commonly used of all the electronic components, to the point where they are almost taken for granted. There are many different Types of Resistor available for the electronics constructor to choose from, from very small surface mount chip resistors up to large wire wound power resistors.

3.7.7 Thermal detector

Thermal detectors as shown in Figure (3.14) are devices that respond to heat typically 135°F. These units consist of a bimetallic element that bends to complete a circuit under high heat conditions. Because these units do not detect smoke or products of combustion, they are not recommended for living areas of a residence. However, they do have value for use in attics, unheated garages, and furnace rooms.



Figure (3.14) Thermal detector

3.7.8 Smoke Detectors

One type of photoelectric smoke detector as shown in Figure (3.15) consists of a photoelectric cell and an external light source. When light received by the cell drops to a predetermined value, for example when smoke blocks the light from the light source, relays will cause the alarm to sound. Because of this, it is important to keep the light source and cell lens clean. Also, the lamp in the light source should be replaced regularly before failure.



Figure (3.15) Smoke detectors

3.7.9 Notification Appliance

A fire alarm system component as shown in Figure (3.16) such as a bell, horn, speaker, light or text display that provides audible, tactile, or visible outputs, or any combination thereof.



Figure (3.16) Notification Appliance

3.7.10 Relay

A relay is an electrically operated switch as shown in Figure (3.17) many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal. The first relays were used in long distance telegraph circuits as amplifiers: they repeated the signal coming in from one circuit and re-transmitted it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

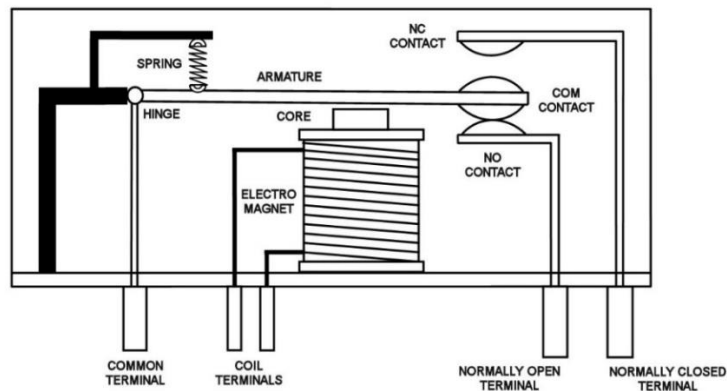


Figure (3.17) Relay

CHAPTER FOUR

SYSTEM SIMULATION AND IMPLEMENTATION

4.1 Introduction

The MikroC PRO is a powerful, feature-rich development tool for PIC microcontrollers. It is designed to provide the programmer with the easiest possible solution to developing applications for embedded systems, without compromising performance or control, MikroC PRO for PIC is a complete Integrated development environment (IDE) for coding, simulating, programming, and debugging the PICs.

4.2 Code Structure

The first thing in the programming code is to identify the devices connected to the microcontroller and specify which pins connected to every device. Then each pin is identified as an input or output pin and each variable are identified. After that the microcontroller receives the reference values from the keypad to enter the password code so user can be able to access to BMS. The sensors and detectors send signals for latching conditional units depending on heat sensor values so the system can choose if this value of temperature needs to initiate another unit or not in order to decrease the temperature of building and display that on Liquid crystal display (LCD), or warning public if smoke or heat detectors is sent signal to fire alarm control panel which is latching the buzzer to take action into start the damping of fire.

4.3 System Simulation

The Proteus schematic capture module lies at the heart of the system. It combines the design environment with the ability to define most aspects of the drawing appearance. Proteus provides a full real life simulation. From the tools components library added pic 16F877A to schematic capture (workspace) as shown in Figure (4.1).

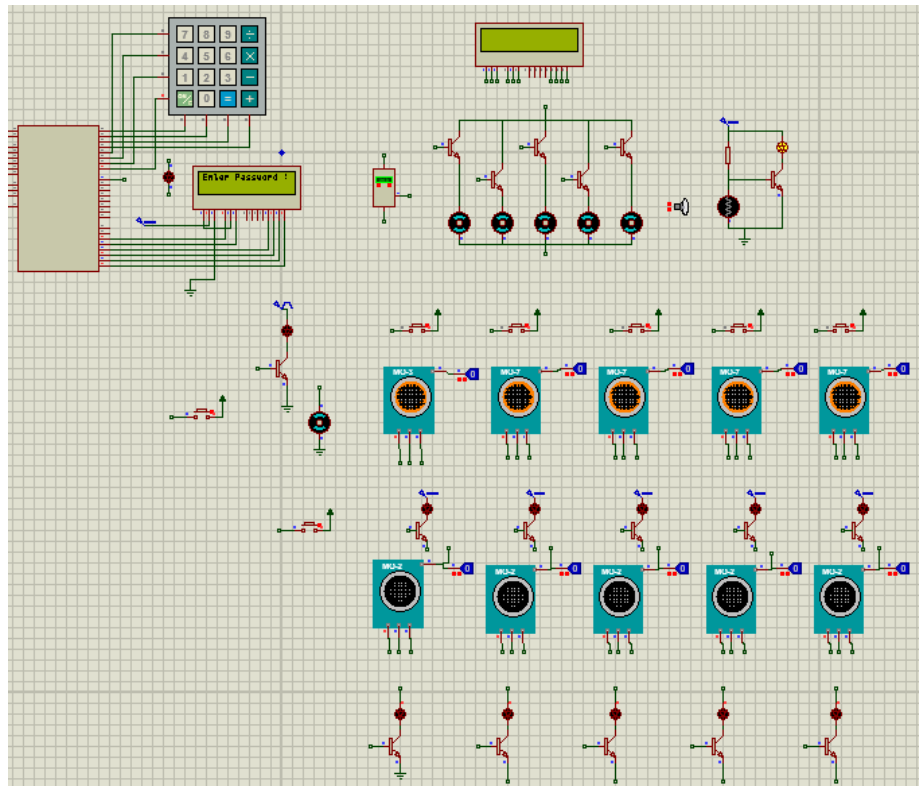


Figure (4.1) schematic capture

Then Keypad is added in circuit and connected to the pic by considering the keypad array and resistors location as shown Figure (4.2), LM016L LCD display attached with the pic display 'Enter Password' then the user enter the right password to access system.

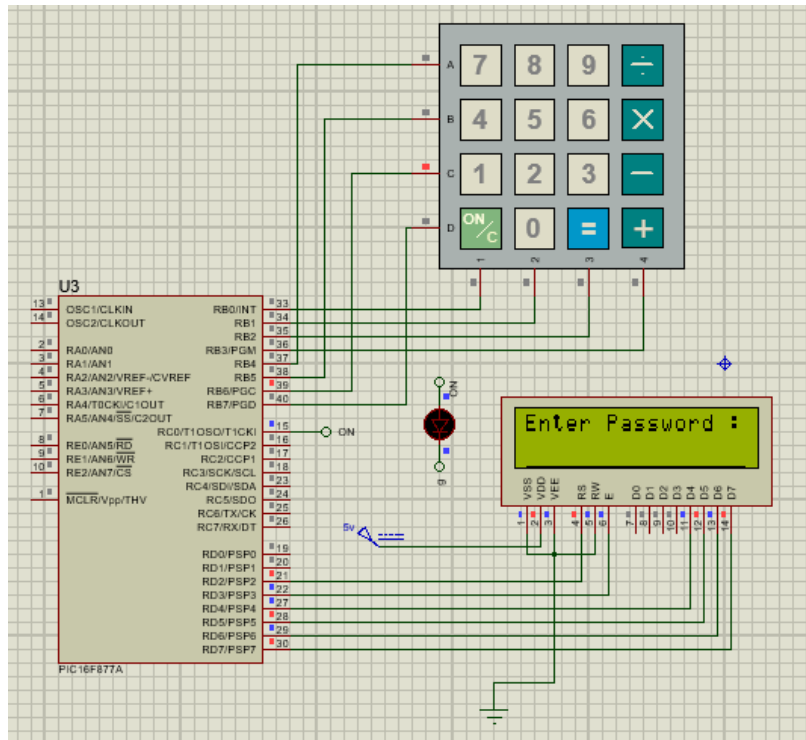


Figure (4.2) Access System

Then temperature sensor type LM35, gives the micro input signal to active the air condition as shown in Figure (4.3). This sensor output refer's to five outputs pins which is connected with conditional unites which installed to decrease the Temperature of building according to table (4.1) as shown below, Figure (4.3) show the incorporated between sensor and LCD in order to read the room temperature at the time and how many conditional units work.

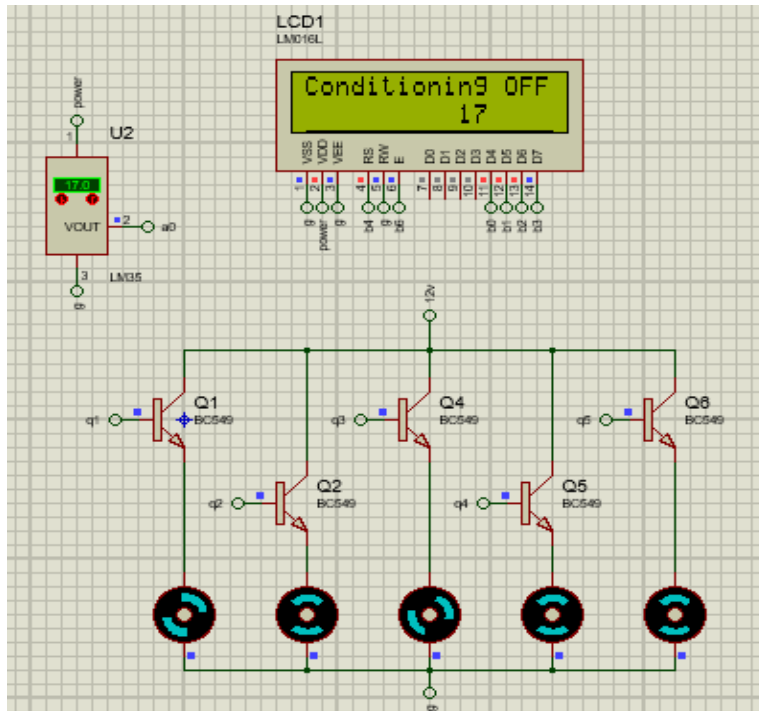


Figure (4.3) Air Conditioning Units

Table (4.1) Temperature building

TEMP. RANGE	UNITES
0-19	All units off
20-24	Unite one on
25-29	Unite one +two
30-34	Unite one +two +three
35-39	Unite one +two +three +four
40-45	Unite one +two +three +four +five

If the fire increased and the temperature of room becomes high the heat detectors send signal to micro in order to initiate the buzzer to warning public and initiate the pump riser with water in order to damp the fire and stopping the notification

appliance. However the system includes manual call point manually operate device used to initiate an alarm signals in all over the building, when this button set, there is a reset switch for reset all fire alarm system components. The fire alarm system is represented and shown in Figure (4.4).

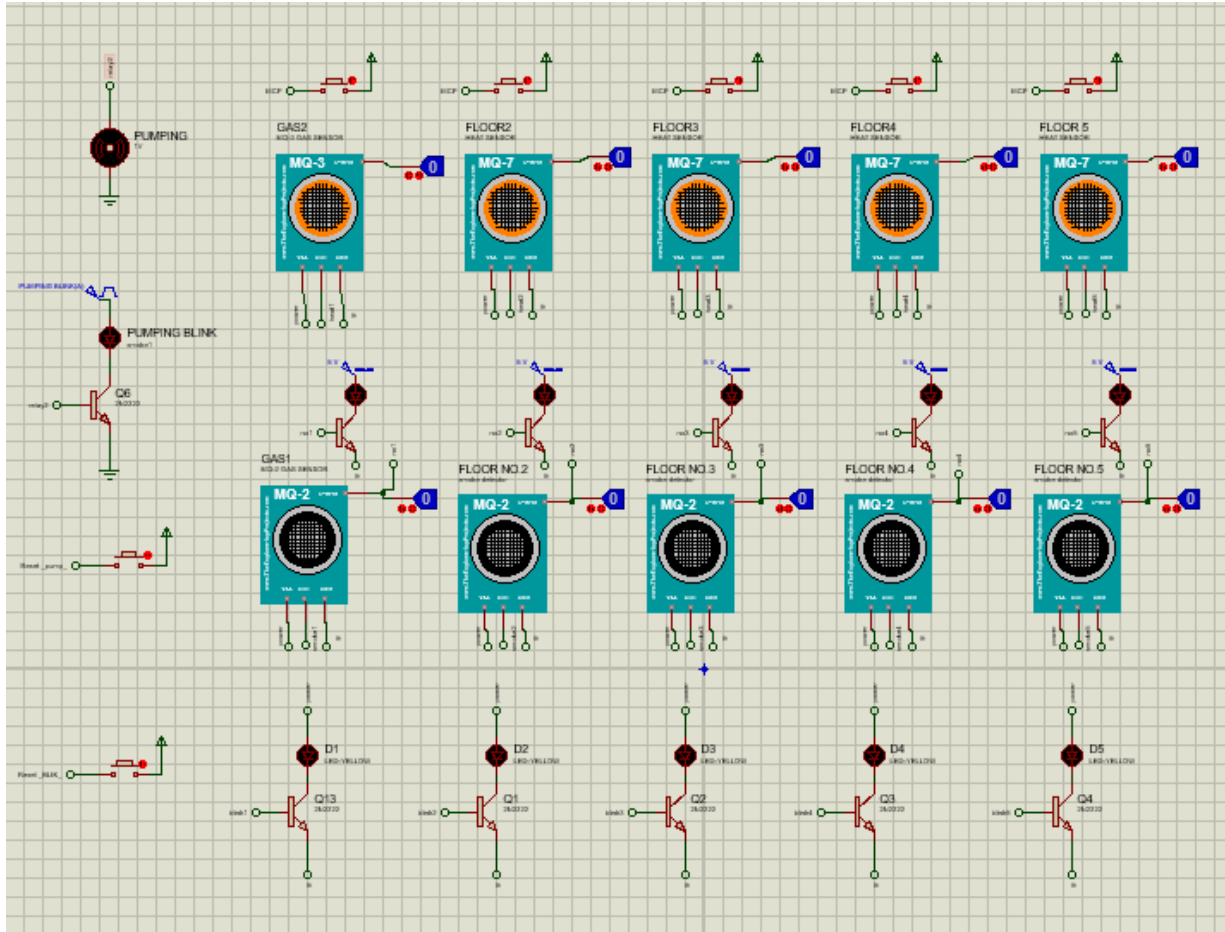


Figure (4.4) Fire Alarm System

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

- A simpler operation with routine and repetitive functions programmed for automatic operation of BMS can reduced operator training time through on-screen instructions and supporting graphic displays.
- The BMS has faster and better responsiveness to occupant needs and trouble conditions, the cost of energy was reduced through centralized management of control and energy management programs.
- Better management of the facility through historical records, maintenance management programs, and automatic alarm reporting.

5.2 Recommendations

- Apply a BMS in other areas of applications such as communication towers.
- Apply other types of controllers to control the main components of the BMS.
- Implement a lifting systems and closed circuit of television CCTV for future researches.

Appendix

▪ Security Code

```
sbit LCD_RS at RD2_bit;
sbit LCD_EN at RD3_bit;
sbit LCD_D4 at RD4_bit;
sbit LCD_D5 at RD5_bit;
sbit LCD_D6 at RD6_bit;
sbit LCD_D7 at RD7_bit;
// Pin direction
sbit LCD_RS_Direction at TRISd2_bit;
sbit LCD_EN_Direction at TRISd3_bit;
sbit LCD_D4_Direction at TRISd4_bit;
sbit LCD_D5_Direction at TRISd5_bit;
sbit LCD_D6_Direction at TRISd6_bit;
sbit LCD_D7_Direction at TRISd7_bit;
char keypadPort at PORTB;
int i;
char password[5];
int count=2;
void main()
{
    trisc.b0=0;
    trisE=7;
    portc.b0=0;
    Lcd_Init();
    keypad_Init();
```

```

Lcd_Cmd(_LCD_CURSOR_OFF);
Loop:
password[0]=0;
    password[1]=0;
    password[2]=0;
    password[3]=0;
Lcd_Cmd(_LCD_CLEAR);
Lcd_Out(1, 1, "Enter Password :");
    for(i=0;i<=3;i++)
    {
        while (password[i] == 0)
        {
            password[i] = Keypad_Key_Click();
        }

        if(password[i]==1)    password[i] = '7';
        if(password[i]==2)    password[i] = '8';
        if(password[i]==3)    password[i] = '9';
        if(password[i]==5)    password[i] = '4';
        if(password[i]==6)    password[i] = '5';
        if(password[i]==7)    password[i] = '6';
        if(password[i]==9)    password[i] = '1';
        if(password[i]==10)   password[i] = '2';
        if(password[i]==11)   password[i] = '3';
        Lcd_Chr(2,i+1,'*');
    }
if(strcmp(password,"1235") == 0)

```

```

{
if (count%2==0)
{
Lcd_Cmd(_LCD_CLEAR);
Lcd_Out(1,2 , "SYSTEM ON");
portc.b0 = 1;
count+=1;
delay_ms(3000);
goto loop;
}
else
{
Lcd_Cmd(_LCD_CLEAR);
Lcd_Out(1,2 , "SYSTEM OFF");
portc.b0 = 0;
count+=1;
delay_ms(3000);
goto loop;
} } else
{
password[0]=0;
password[1]=0;
password[2]=0;
password[3]=0;
goto Loop;
}
}

```

▪ HVAC Code

```
sbit LCD_RS at RB4_bit;
sbit LCD_EN at RB5_bit;
sbit LCD_D7 at RB3_bit;
sbit LCD_D6 at RB2_bit;
sbit LCD_D5 at RB1_bit;
sbit LCD_D4 at RB0_bit;

sbit LCD_RS_Direction at TRISB4_bit;
sbit LCD_EN_Direction at TRISB5_bit;
sbit LCD_D7_Direction at TRISB3_bit;
sbit LCD_D6_Direction at TRISB2_bit;
sbit LCD_D5_Direction at TRISB1_bit;
sbit LCD_D4_Direction at TRISB0_bit;

long x,t;
char temp[14] ;
void main()
{
trisa=0xff;
trisb=0;
trisc=0;
portb=0;
portc=0;
lcd_init();
lcd_cmd(_lcd_cursor_off);
```

```

while(1)
{
x=adc_read(0);
t=(500*x)/1023;
longtostr(t,temp);
if(t<=19)
{
lcd_out(1,1,"Conditioning OFF");
lcd_out(2,2,temp);
delay_ms(1500);
lcd_cmd(_lcd_clear);
portb.B6=0;
portb.B7=0;
portc.B0=0;
portc.B1=0;
portc.B2=0;
}
if(t>=20&& t<=24)
{
lcd_cmd(_lcd_clear);
lcd_out(1,1,"One Unite ON");
lcd_out(2,2,temp);
portb.B6=1;
portb.B7=0;
portc.B0=0;
portc.B1=0;
portc.B2=0;
}
}

```



```

}
if(t>=25&&t<=29)
{
lcd_cmd(_lcd_clear);
lcd_out(1,1,"Two Unites ON");
lcd_out(2,2,temp);
portb.B6=1;
portb.B7=1;
portc.B0=0;
portc.B1=0;
portc.B2=0;
}
if(t>=30&&t<=34)
{
lcd_cmd(_lcd_clear);
lcd_out(1,1,"Three Unites ON");
lcd_out(2,2,temp);
portb.B6=1;
portb.B7=1;
portc.B0=1;
portc.B1=0;
portc.B2=0;
}
if(t>=35&&t<=39)
{
lcd_cmd(_lcd_clear);
lcd_out(1,1,"Four Unites ON");

```

```
lcd_out(2,2,temp);
portb.B6=1;
portb.B7=1;
portc.B0=1;
portc.B1=1;
portc.B2=0;
}
if(t>=40&&t<=45)
{
lcd_cmd(_lcd_clear);
lcd_out(1,1,"Five Unites ON");
lcd_out(2,2,temp);
portb.B6=1;
portb.B7=1;
portc.B0=1;
portc.B1=1;
portc.B2=1;
}
}
}
```

▪ Firefighting Code

```
void main()
{ trisb=255;
trisc=0;
trisd=255;
portc=0;
while(1)
{
if(portb.B0==1)
{portc.b0=1;  delay_ms(100);  portc.b0=0;}
if(portb.B1==1)
{portc.b1=1;  delay_ms(100);  portc.b1=0;}











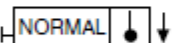

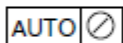





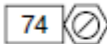




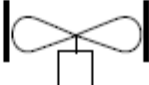

if(portb.B2==1)
{portc.b2=1;  delay_ms(100);  portc.b2=0;}

if(portb.B3==1)
{portc.b3=1;  delay_ms(100);  portc.b3=0;}

if(portb.B4==1)
{portc.b4=1;  delay_ms(100);  portc.b4=0;}
else
if((portd.B0==1)||(portd.B1==1)||(portd.B2==1)||(portd.B3==1)||(portd.B4==1)||(po
rtd.B5==1))
{ portc.b7=1;  delay_ms(100);  portc.b7=0;}
}
```

}

Symbol

	CONTROLLER, TEMPERATURE		FAN
	SENSOR, TEMPERATURE		PRESSURE CONTROLLER, HIGH LIMIT CUT-OUT, MANUAL RESET
	LOW LIMIT		PRESSURE SENSOR
	HIGH LIMIT		INSERTION TEMPERATURE SENSOR
	MANUAL RESET NOTATION		TEMPERATURE SENSOR, AVERAGING
	TEMPERATURE CONTROLLER, MANUAL RESET, SAFETY LOW LIMIT		COOLING COIL
	MANUAL MULTI-STATE COMMAND (ON-OFF-AUTO)		HEATING COIL
	STATUS POINT		FILTER
	VALUE POINT (% LOAD)		PUMP
	COMMANDABLE VALUE		SOLENOID VALVE
	3-WAY VALVE WITH ACTUATOR		SMOKE DETECTOR (NFPA SYMBOL)
	2-WAY VALVE WITH ACTUATOR		PROPELLER EXHAUST FAN
	DAMPER WITH ACTUATOR		

M10437

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- [1] Honeywell engineering manual of automatic control for commercial buildings.
- [2] Terry Kennedy john E.traister, Low voltage wiring security/fire alarm system third edition.
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- [4] Robert McDowall Fundamentals of HVAC systems. 2006.