Controller of Heating, Ventilation and Air Conditioning for A building

By using Microcontroller

المتحكم في التدفئة والتهوية وتكييف الهواء لمبنى باستخدام متحكم دقيق

A Thesis submitted in partial

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ABSTRACT

This research concerns the controller of HVAC for Building by using Microcontroller, which uses the difference between the set value and the present value building temperature. The difference is assumed to affect the compressors, Heaters, Fans in order to achieve the desired set point. The project involves protection alarm system for HVAC system, designing a controller and performing a simulation to analyses the performance of the designed controller using Bascom-AVR Language and Proteus/Simulink. The controller is based on LM35 Temperature Sensor to control the temperature building. The result shows that the controller is able to get a suitable temperature according to set point temperature and the Controller give protection for HVAC system.

المستخلص

يتهم هذا البحث بدراسة نظام التكييف والتدفئة لمبنى ما باستخدام المتحكمة الدقيقة ، حيث تقوم هذه المتحكمة الدقيقة بمقارنة الفرق بين درجة الحرارة المضبوطة مع درجة الحرارة الفعلية للمبنى. وهذا الفرق بدوره يؤثر على الضواغط ، السخانات والمرواح من أجل تحقيق درجة الحرارة المضبوطة في هذا النظام.

يشمل المشروع ايضا نظام انذار لحماية لوحدة التكييف والتدفئة ، وايضا تم تصميم دائرة المشروع بواسطة برنامجي البروتس والباسكوم لتقييم اداء هذه المتحكمة والتي تعتمد على حساس حراري LM35 للتحكم في درجة الحرارة للمبنى. والنتائج تبين لنا ان المتحكمة قادرة علي تحقيق درجة الحرارة المطلوبة والتي تعتمد بدورها على درجة الحرارة المضبوطة للمبني ، كما ان المتحكمة لها المقدرة على توفير الحماية المناسبة للنظام.

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List of Abbreviations

HVAC	Heating Ventilation Air Conditioning
LCD	Liquid crystal display
LED	Light Emitting Diode
RS	Register Select
R/W	Read/Write
E	Enable
I/O	Input/Output
SPST	Single pole
NO	Normal Open
A/D	Analog to Digital converter
PV	Present Value
SV	SET Temperature Value
HT	Heater Element
CP	Compressors
CF	Condenser Fans
EF	Evaporator Fans
RS	Reset switch
HP1	High pressure switch 01
HP2	High pressure switch 02
LP1	Low pressure switch 01
LP2	Low pressure switch 02
MP1	Motor Protection switch 01
MP2	Motor Protection switch 02
TMP1	Thermal Motor Protection switch 01
TMP2	Thermal Motor Protection switch 02
TMP3	Thermal Motor Protection switch 03
ID1	Indoor temperature sensor 01
ID2	Indoor temperature sensor 02

Chapter One

Introduction

1.1Introduction:

For Centuries buildings served as basic shelters to protect occupants from the extremes of the outdoor environment. Control of the indoor environment was chiefly dependent upon open fires for heat, and natural air natural circulation for ventilation.

The emerging technology of the twentieth century allowed the development of the heating, ventilating and air conditioning (HVAC) system capable of maintaining fully controlled indoor environment. So the heating, ventilating and air conditioning (HVAC) system control the temperature and quality of air in especially important in medium to large buildings such as office, residential towers.

The HVAC system is divided on three parts: The Outdoor Unit which is consist of set of Compressors with Temperature sensor switch, Crankcase Heater & Pressure switches as protect of Compressors, Condenser Fan Motors with Temperature sensor switch as protect of Motors, Condenser Coil & Solenoid Valves. The second part is consisting of Evaporating Fan Motors with Temperature sensor switch as protect of Motors, Evaporating Coil , Expansion Valves & group of temperature sensors to measuring actual temperature and protect indoor system. The third part is Control panel is consisting of Controller with LCD to monitor status of system, control Circuit & Main Power Circuit.

Most of HVAC (Heating, Ventilation Air Conditioning) uses PLC to control the Temperature of Large Building & that is very expensive. So the Purpose of Research is decrease the cost of Controller by uses Microcontroller .The basic object of this project is to control Heaters, Fans, Solenoid valves & Compressors to maintain constant temperature in an environment within the acceptable range according to set point requirement. In addition to Monitoring & Protection of HVAC System.

For this I uses microcontroller as the main controller and protection of HVAC system. One temperature sensor to give actual temperature on Building. One LCD is attached with the microcontroller to display the set temperature value & present temperature value. In addition to monitoring the status of HVAC system & giving alarm when troubleshooting happen on HVAC system.

For Heaters, Fans, Solenoid valves & Compressors I uses group of Relays to Control it.

1.2 Statement of Problem:

Most of HVAC (Heating, Ventilation Air Conditioning) uses PLC to control the Temperature of Large Building & that is very expensive. In addition to the PLC take large space & more power consumption contrast with microcontroller. So the Purpose of Research is decrease the cost, space & power consumption of Controller by uses Microcontroller .The main functions of Microcontroller maintain the temperature within the acceptable range according to set point requirement. In addition to Monitoring & Protection of HVAC System.

1.3 Objective:

The objectives of this project are:

1. To design controller using Bascom & Proteus Simulink of HVAC system.

2. Due to microcontroller give as the same performance contract with PLC.

3. Monitoring & Protection each Electrical Device on HVAC system

4. Easy to deal with microcontroller.

5. To easy programming microcontroller.

1.4 Methodology:

Below are the scopes of the project:

1. The controller used is Microcontroller

2. Proteus simulation program is used to simulate the performance of the controller.

3. Inside and outside room temperature are used in the controller design.

4. The analysis controller performance in terms of automatic temperature control based on the HVAC system.

1.5 Thesis (Research Plan):

The report begins with the thesis background which includes an introduction to HVAC system. The section states the objective of the project. The scope of the design, which consists of four aspects that related with the design of the controller, is also stated.

Chapter 2 is presents the literature reviews, highlighting related research on this project taken from books and the journals.

Chapter 3 is talk about the Hardware of HVAC system, which included the Mechanical & Electrical Component of HVAC System.

Chapter 4 discusses about the software design for Controller of HVAC system. It shows the flow chart that illustrates the whole research process. The method to design the controller of HVAC system is discussed in this chapter.

Chapter 5 presents the result and analysis that have been done by simulation using proteus. This chapter also discusses about the controller output and the performance of the controller.

The last chapter summarizes and concludes this thesis with recommendations for future works.

Chapter Two

Literature Review

2.1 Principles of HVAC System:

HVAC system involves more than lowering the air temperature. It includes dehumidifying, cleaning (filtering), and circulating the air. Good HVAC Systems perform all of these functions, although most people focus on the cool concept. In the broadest sense of the term, air conditioning also means heating, humidification, and ventilation. The HVAC system has many dynamical variables and a typical nonlinear time variable multivariate system with disturbances and uncertainties. It very difficult to find the mathematical model to describe the process over wide operating range. The goal with HVAC system is to capture heat in the house and throw it outside. The difference between the HVAC and cooling system are the HVAC system for an application for the cooling system as a control system for the movement of air, moisture and temperature changes in a sanitary particular space and the cooling system. The basic vapor compression designed to cool down the environment through exposure to a boiling liquid. System is required to produce the temperature of a space.

The schematic of HVAC system is illustrated in Figure 2.1, which shows that the HVAC is a complex system. Based on the schematic of system HVAC, the main material that effect the cooling system is Freon gas.

On the inside of a coil a substance such as Freon 12 or Freon 22 which is brand names for a refrigerant are used. This refrigerant is a colorless gas at atmospheric temperature and pressure. The coils inside manipulate the Freon to make it a liquid or a gas. The Freon runs in a loop, passing through the indoor coil, through a copper pipe to the outdoors, through the outdoor coil, and back inside through another pipe to the indoor coil.

The main components are evaporator coil, blower fan, compressor and condensing coil. The compressor is the main component for the cooling system.

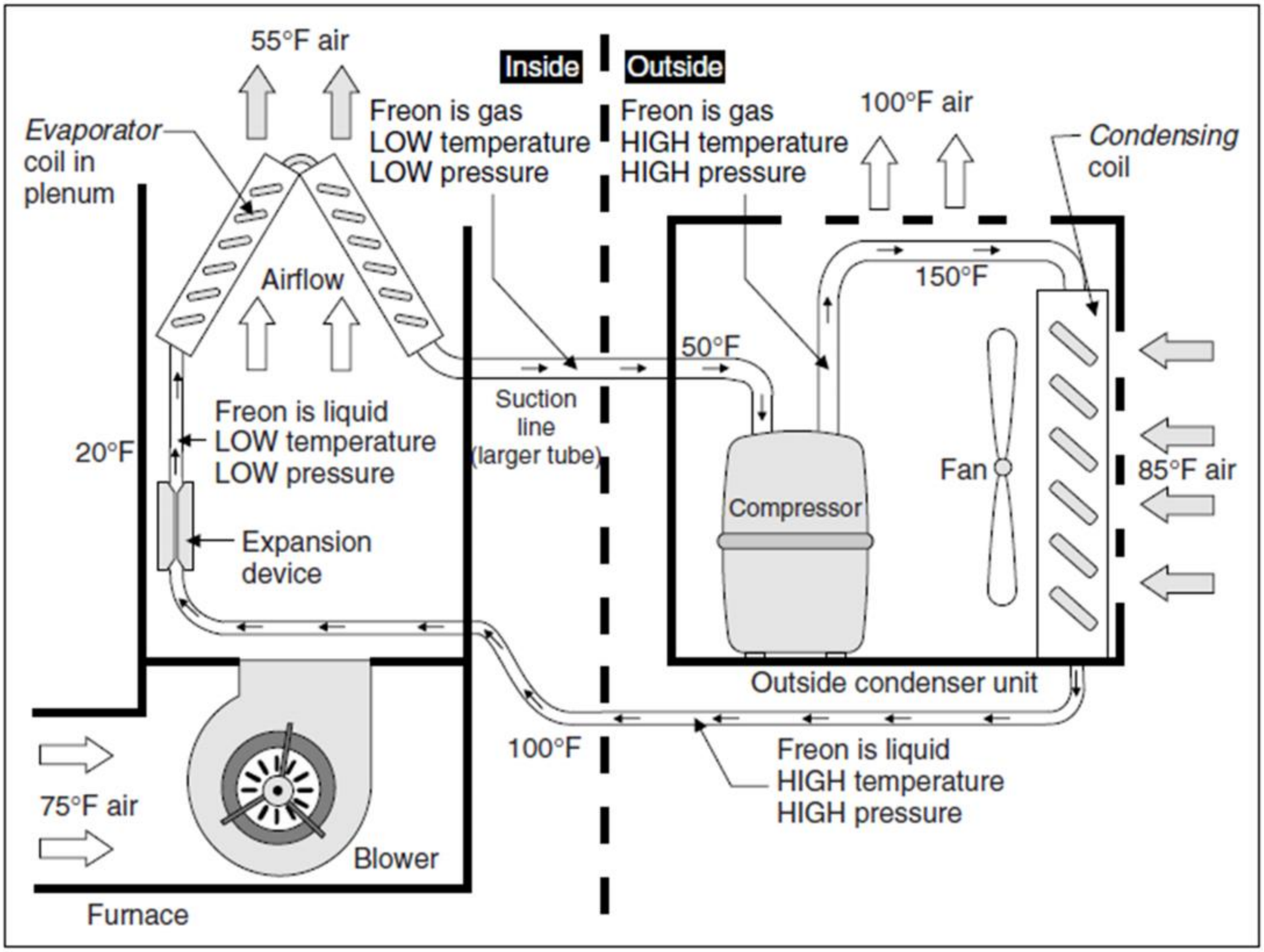


Figure 2.1: Schematic of HVAC System.

HVAC system is process the transfer heat. Two coils are installed at inside and outside building. The transfer head occur from the inside and the outside building through the piping. The warm air from inside building is through indoor coil and the warm air discharge outside building through the outdoor coil. The function of fans is blowing air across the evaporator and condenser coil when the HVAC system is running. The evaporator coil and condenser coil in a HVAC are heat exchangers. The function of refrigerant that collect heat from the building, moves it outside and releases it into the outdoor air. The compressor is squeezing a cool low pressure gas into hot high pressure gas. The expansion device at near the evaporator coil is converting a hot high pressure liquid to cool low pressure liquid. The Freon gas convert to Freon liquid after final process cooled air for surrounding room.

2.2 Function of Compressor that Effect the Temperature:

The function of compressors are similar to pumps both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of a gas. Liquids are relatively incompressible while some can be compressed, the main action of a pump is to pressurize and transport liquids. The compressor will inhaling refrigerant from the evaporator coil and then compressing it into the condenser coil. The compressor is usually driven by electric motors that require high electrical power to drive the compressor. The compressor is usually controlled by a thermostat that measures the room air temperature. If the room temperature was quite cold, the thermostat will turn off the compressor. Adjusting the motor speed can control the refrigerant mass flow rate. The refrigerant mass flow rate, in turn is the main factor governing heat exchange in the condenser and evaporator, which exchange determines temperature. In summary then, adjustments of compressor motor speed can control the temperature of an air conditioned room.

The basic of the vapor compression are designed to cool down the environment through the boiling liquid. This system is required to produce the temperature that need for ambient space. Figure 2.2 illustrates the flow of cooling system in which the compressor is the main component. The operation of compressor when is turned on, it will be interesting to inhale refrigerant from the evaporator coil and compressed it to condenser coil. The temperature of evaporator coil will become cold and condenser coil will get hot. The fan at evaporator coil draws air outside to coil and the cold air will occur. The fan at condenser oil draws air outside to reduce the refrigerant temperature in the coil. The high pressure refrigerant that comes from the outside condenser coil will change to the low pressure refrigerant. When the temperature room was quite cool, the thermostat will turn off the compressor. When the room temperature rises above of the desired level of cold, the thermostat will turn on the compressor. The suitable control algorithm, the compressor can function at the power level that required maintaining the desired ambient temperature.

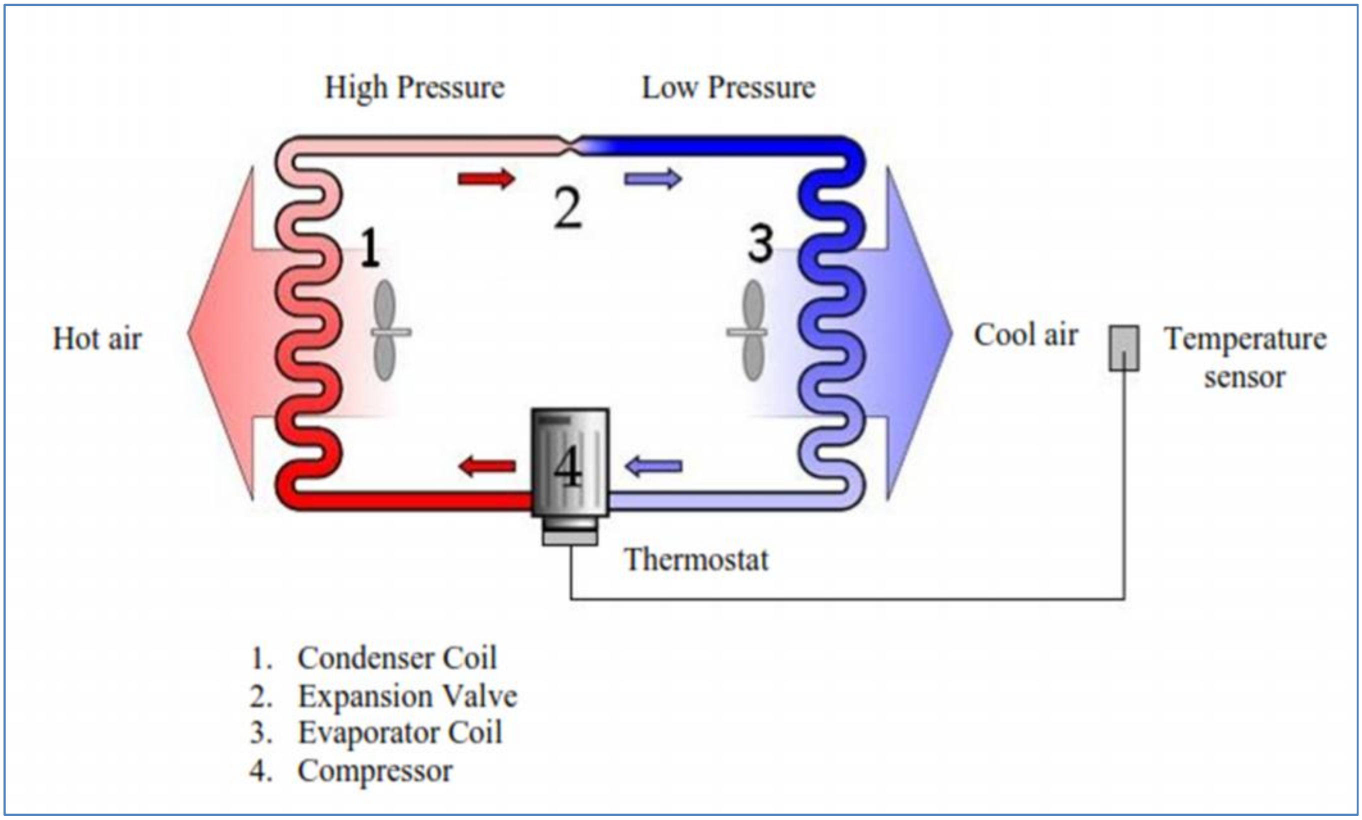


Figure 2.2: The process of cooling system.

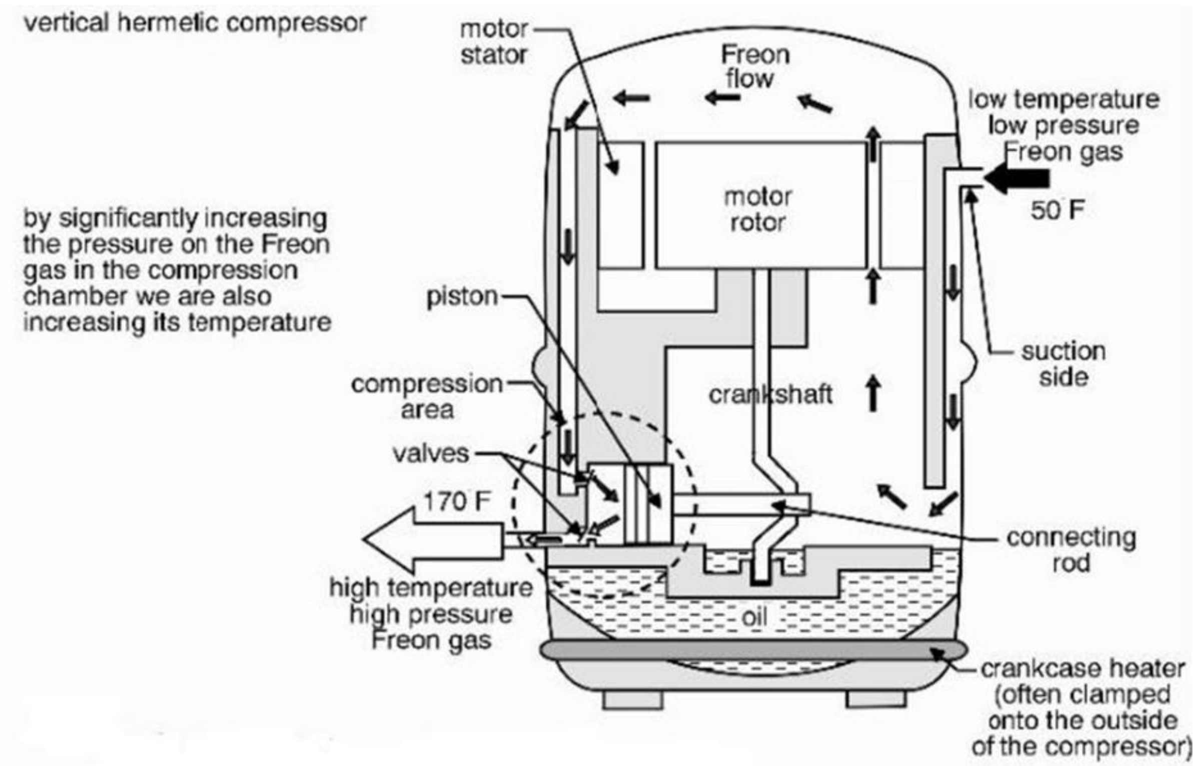


Figure 2.3: The flow of the Freon in compressor.

Figure 2.3 shows the flow of the Freon gas and the changing of temperature and pressure in compressor. When the compressor is compressing, the pressure and temperature are high. At early entry compressor, the pressure and temperature are low and then it flows to the compression area. Motor are moving and the piston will move up and down in compression chamber and it will be increasing the temperature and pressure.

2.3 Factors Affecting Cooling Load

The cooling capacity of air conditioners is usually measured in tons. One ton equals12, 000 BTU (British Thermal Units) per hour. The term one ton comes from the amount of heat required to melt a block of ice that weighs one ton. The amount of cooling required depends on a large number of factors. These include the outdoor temperature, the outdoor humidity, the level of insulation in the house, the amount of air leakage in the house, the amount of southern, eastern, and western facing glass in the house whether this glass is single, double, or triple glazed, whether the glass is a low emissivity glass; and whether window treatments (curtains or blinds) are kept closed or open. Other factors include the amount of shading from trees, roof overhang, awnings, or buildings and how much heat is generated in the house by the people and equipment inside. All this factors are affecting the cooling load and to calculate the value of BTU in the room, we must consider for all this factors.

2.4 Microcontroller:

Microcontroller devices, essentially tiny microcomputers with additional control features, are widely used by today's electrical engineers. They replace many analog and digital components and have far more advanced functions than those available decades ago. Microcontrollers can handle complex algorithms and cope with more input and output signals that are necessary for medium-complexity control systems. Different functions can be implemented by altering the programs that drive the microcontrollers, and the capability of performing variable functions makes a microcontroller a nearly universal device in many industrial and domestic applications. Since the first microprocessor unit, Intel's 4004, was introduced in 1970, microprocessors have become a fundamental device for engineering design (Fox, 2000). Recent advances in semiconductor technology have resulted in more powerful, integrated microcontroller circuits.

The Intel 8085, or Zilog Z80 microprocessors, which dominated the market during the 1980s, have now become essentially obsolete and have been replaced by far more capable and flexible microprocessors, such as the 68HC11. The 68HC11 is generally regarded as the best and most powerful 8-bit microprocessor for general use. For example, millions of 68HC11 have been used in electronic control modules of automobiles. In most mass-produced items that contain a microprocessor, the superior computational capability of a 16-bit microprocessor is often unnecessary. Thus, 8-bit microprocessors, such as the 68HC11, have continued to outsell the 16-bit.

2.5 Microcontroller programming:

The CPU in the microcontroller can only recognize certain groups of bits as valid instructions in machine language. It is difficult to program directly in this binary machine language even for the simplest microcontrollers. Instead, several languages have been developed to “talk” with the microcontroller, e.g., the assembly language. Assembly language is very close to machine language. It allows users to write programs using easily remembered mnemonics for the instructions, and symbolic names for memory locations and variables. It can produce the most efficient codes and allows users to set flags and registers that are inaccessible in high-level languages.

Every microcontroller has its own special assembly language, and no standard for assembly language exists. Usually the program, or source code, is written in Microsoft Notepad or Word, and then translated by an assembler program to produce the output as an object code that the microcontroller can execute. The microcontroller cannot execute assembly language instructions directly; instead, it can recognize object code that has been converted into machine language.

Besides assembly language, C, BASIC and FORTRAN, etc. can also be used to program a microcontroller. These languages need specific compilers to translate the source code into machine language, the only code that a microcontroller can accept. The problem with higher-level languages is that it is cumbersome, sometime even impossible, to implement some convenient functions such as bit operations, and that the translation from the source code to machine language is complex and time consuming. Furthermore, compilers for these programs are always far more expensive than a simple assembler. Consequently, for some medium-size programs, it may be more suitable to program in assembly language.

All microcontrollers include built-in ROMs and RAMs, and most still have EEPROM available. After the program is assembled or compiled, it is usually recorded in the EEPROM and the microcontroller can run by itself after a reset or powering on, even without an auxiliary PC. This makes a microcontroller a convenient and useful device for a number of applications in household appliances and automobiles.

Chapter Three

Hardware of HVAC System

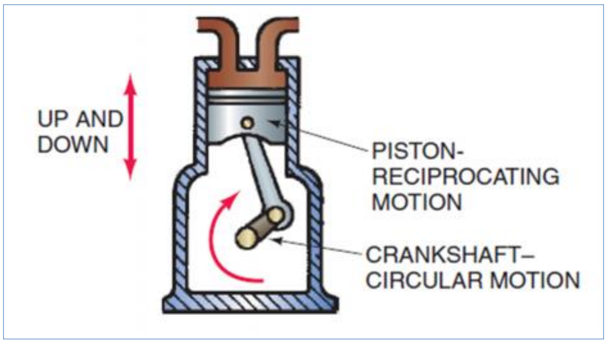
3.1 Mechanical Component of HVAC System:

3.1.1 Compressor Element:

The compressor is the heart of the refrigeration system. It pumps heat through the system in the form of heat-laden refrigerant. A compressor can be considered a vapour pump. It reduces the pressure on the low-pressure side of the system, which includes the evaporator, and increases the pressure on the high-pressure side of the system. This pressure difference is what causes the refrigerant to flow through the system. All compressors in refrigeration systems perform this function by compressing the vapour refrigerant. This compression can be accomplished in several ways with different types of compressors. The most common compressors used in air conditioning and refrigeration are the reciprocating, the rotary and the scroll.

A. Reciprocating compressor:

   The reciprocating compressor uses a piston in a cylinder to compress the refrigerant, Figure (3.1). Valves, usually reed or flapper valves ensure that the refrigerant flows in the correct direction, Figure (3.2). This compressor is known as a positive displacement compressor. Positive displacement compressors increase the pressure of the refrigerant by physically decreasing the volume of the container that is holding the refrigerant. In the case of the reciprocating compressor, the volume is decreased as the piston moves up in the cylinder. The Figure (3.1) has shown the reciprocating compressor.



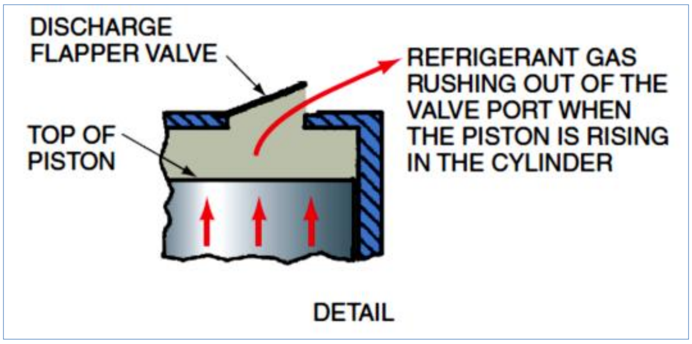


Figure (3.1) show the crankshaft converts the circular, rotating motion of the motor to the reciprocating, or back-and-forth, motion of the piston.

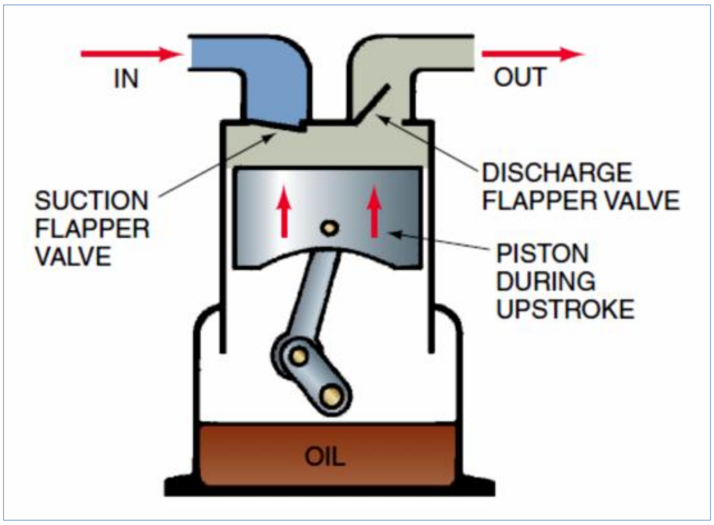


Figure (3.2) illustrated Flapper valves and compressor components.

B. Rotary compressor:

The rotary compressor is also a positive displacement compressor and is used for applications that are typically in the small equipment range, such as window air conditioners, household refrigerators, and some residential air-conditioning systems. These compressors are extremely efficient and have few moving parts, Figure (3.3). This compressor uses a rotating drum like piston that squeezes the refrigerant vapour out the discharge port. These compressors are typically very small compared with the same capacity of reciprocating compressors.

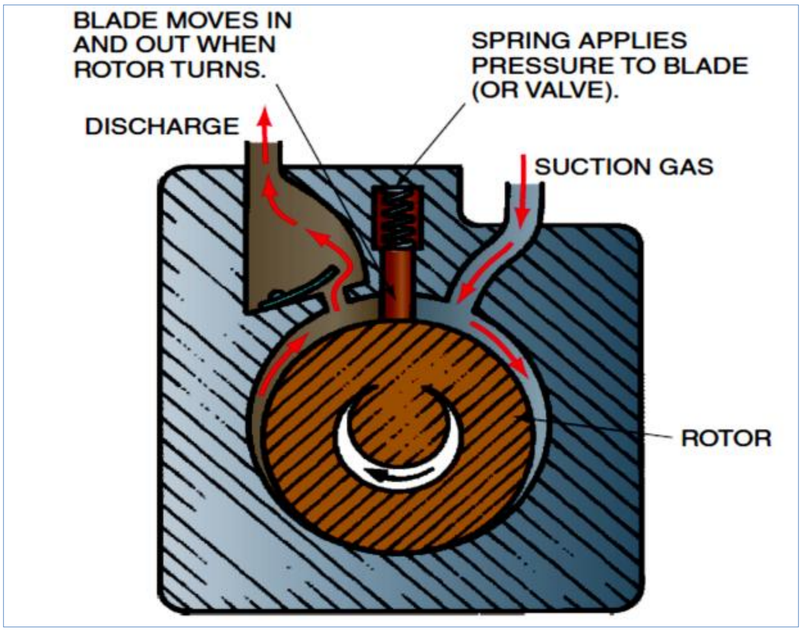


Figure (3.3) illustrate Rotary compressor.

C. Scroll compressor:

The scroll compressor is one of the latest compressors to be developed and has an entirely different working mechanism. It has a stationary part that looks like a coil spring and a moving part that matches and meshes with the stationary part, Figure (3.4). The movable part orbits inside the stationary part and squeezes the vapour from the low-pressure side to the High-pressure side of the system between movable and stationary parts. The scroll is sealed on the bottom and top with the rubbing action and at the tip with a tip seal. These sealing surfaces prevent refrigerant from the high-pressure side from pushing back to the low pressure side while running.

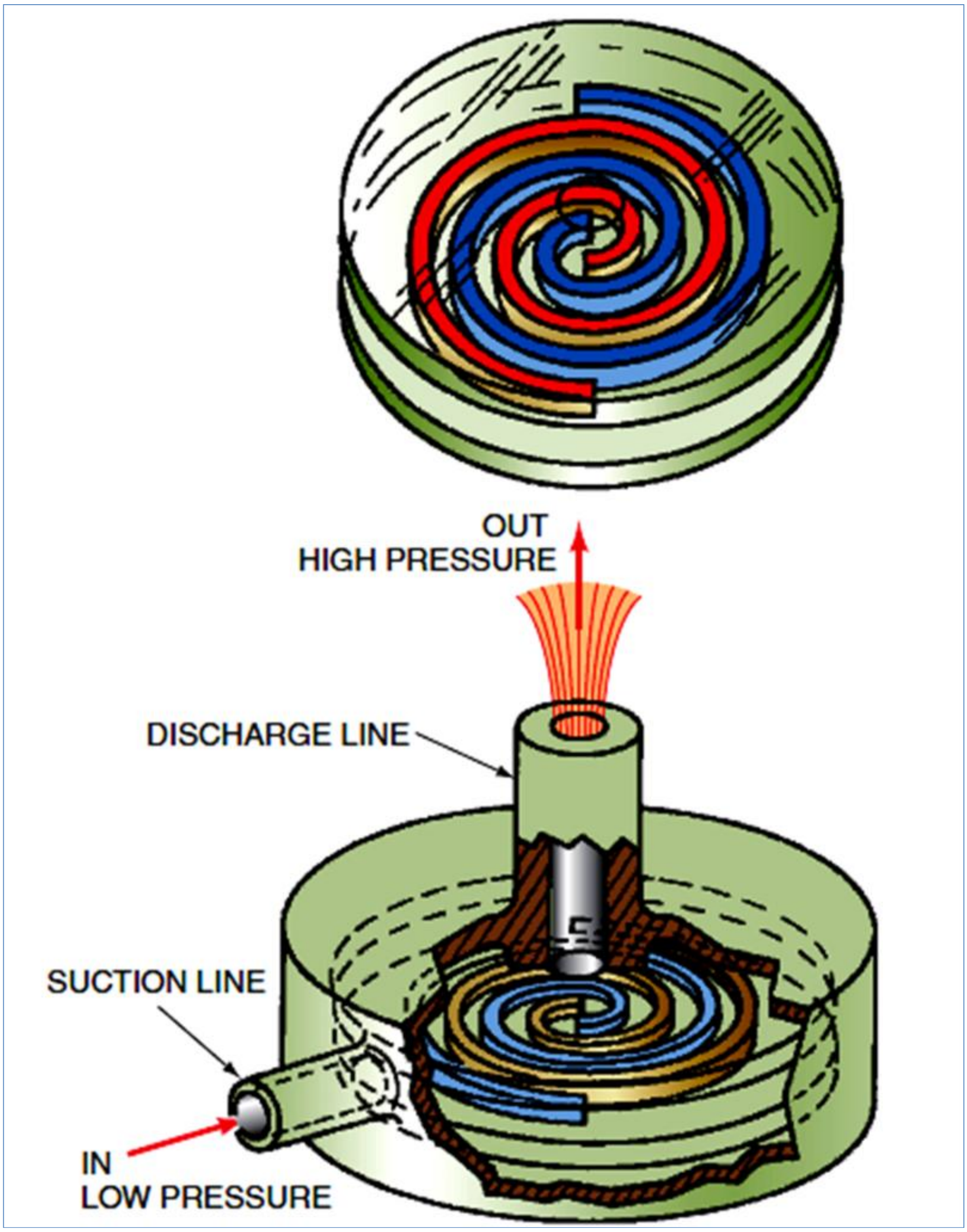


Figure (3.4) an illustration of the operation of a scroll compressor mechanism.

D. Centrifugal compressor:

The centrifugal compressor is used in large air-conditioning systems. It is much like a large fan and is not positive displacement, Figure (2.5). The centrifugal compressor is referred to as a kinetic displacement compressor. These compressors increase the kinetic energy of the refrigerant vapour with the high-speed fan and then convert this energy to a higher pressure. This technology is also used in jet engines.

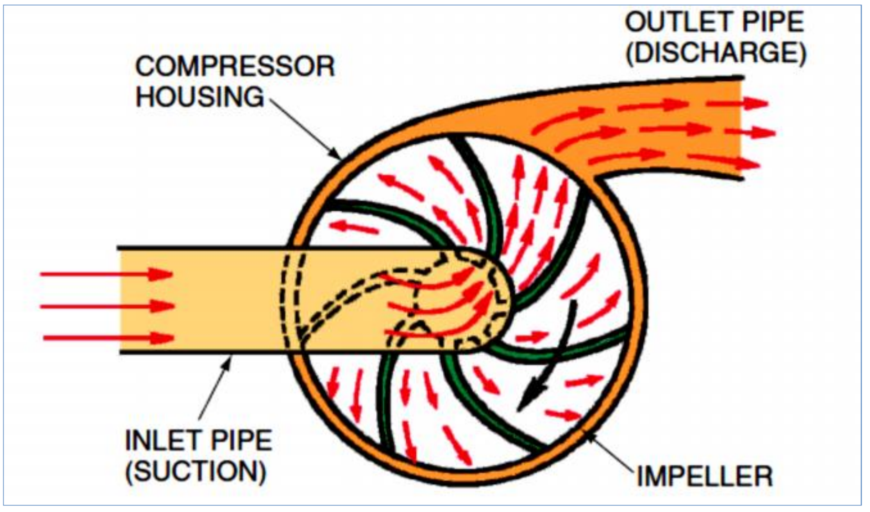


Figure (3.5) an illustration of the operation of a centrifugal compressor mechanism.

E. Screw Compressor:

The screw compressor is another positive displacement compressor and is used for larger air-conditioning and refrigeration applications. The compressor is made up of two nesting “screws,” Figure (3.6). There is a space between the screws that gets smaller and smaller as we move from one end to the other. The vapour refrigerant enters the compressor at the point where the screw spacing is the widest. As the refrigerant flows between these rotating screws, the volume is reduced and the pressure of the vapour increases. The screw compressor is popular for use in low-temperature refrigeration applications. The important thing to remember is that a compressor performs the same function no matter what the type is. For now it can be thought of as a component that increases the pressure in the system and moves the vapour refrigerant from the low-pressure side to the high-pressure side into the condenser.

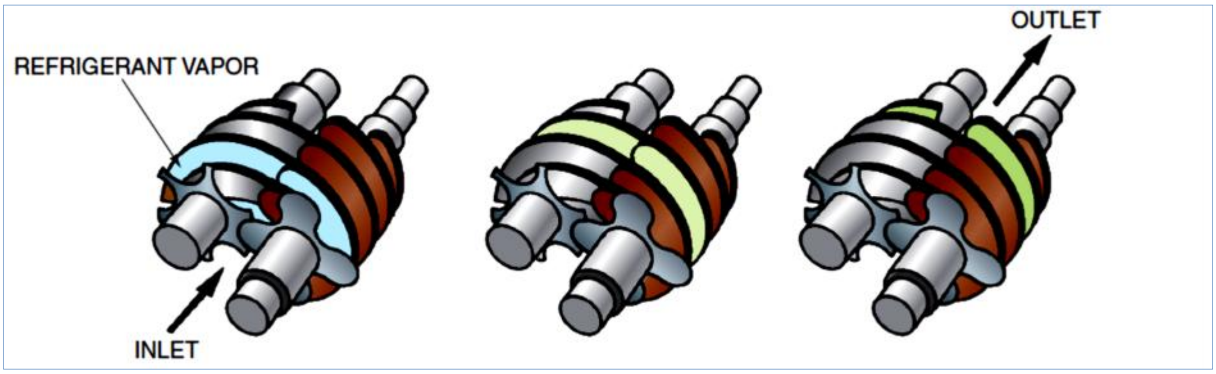


Figure (3.6) an illustration of the internal working mechanism of a screw compressor.

3.1.2 Condenser Coil:

The condenser rejects both sensible (measurable) and latent (hidden) heat from the refrigeration system. This heat can come from what the evaporator has absorbed any heat of compression or mechanical friction generated in the compression stroke, motor-winding heat, and any heat absorbed by superheating the refrigerant in the suction line before it enters the compressor. The condenser receives the hot gas after it leaves the compressor through the short pipe between the compressor and the condenser; this pipe is called the hot gas line, Figure (3.7). This line is also referred to as the discharge line. The hot gas is forced into the top of the condenser coil by the compressor. The discharge gas from the compressor is a high-pressure, high-temperature, superheated vapour. The temperature of the hot gas from the compressor can be in the 200°F range and will change depending on the surrounding temperatures and the system application. The refrigerant at the outlet of the compressor DOES NOT follow a temperature/pressure relationship. This is because the refrigerant is 100% vapour and superheated.

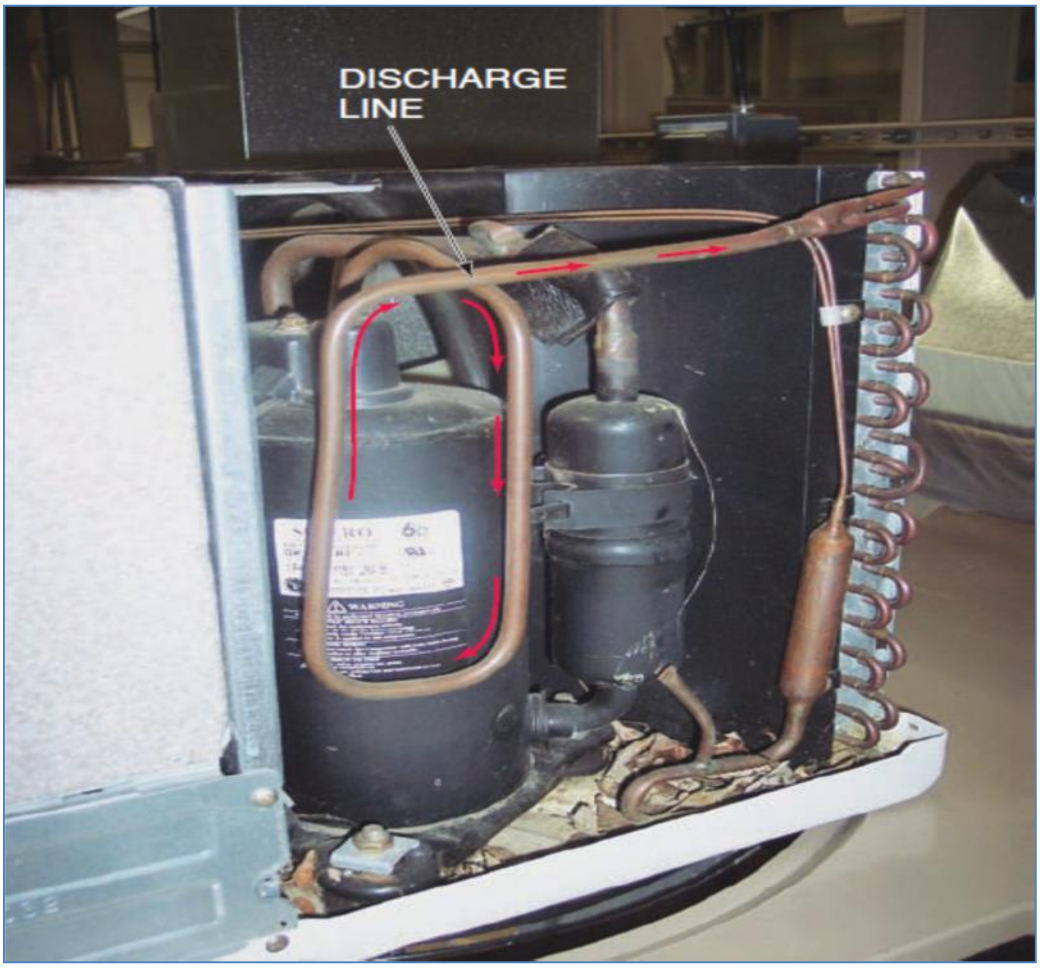


Figure (3.7) show the discharge line connects the outlet of the compressor to the inlet of the condenser.

3.1.3 Liquid Filter:

The refrigerant filter drier can be found at any point on the liquid line after the king valve. The filter drier is a device that removes foreign matter from the refrigerant. This foreign matter can be dirt, flux from soldering, and solder beads, filings, moisture, parts, and acid caused by moisture. Filter driers can remove construction dirt (filter only), moisture, and acid.

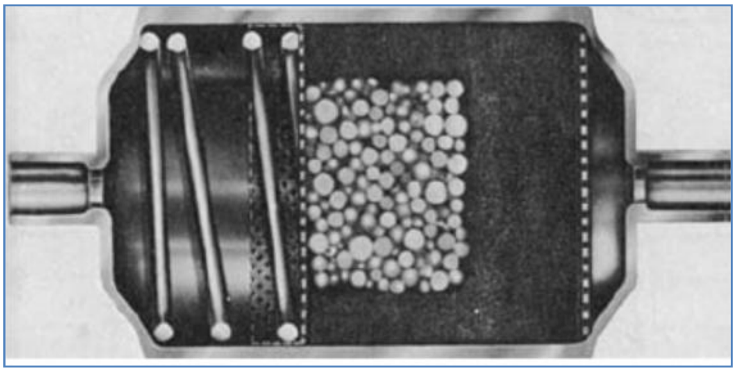


Figure (3.8) show the dryer Filter.

3.1.4 Expansion Valve:

A thermal expansion valve (often abbreviated as TEV, TXV, or TX valve) is a component in refrigeration and air conditioning systems that control the amount of refrigerant flow into the evaporator thereby controlling the superheating at the outlet of the evaporator. Thermal expansion valves are often called the metering device. The expansion device is one of the division lines between the high side of the system and the low side of the system (the compressor is the other). Figure (3.9) shows the location of the device.

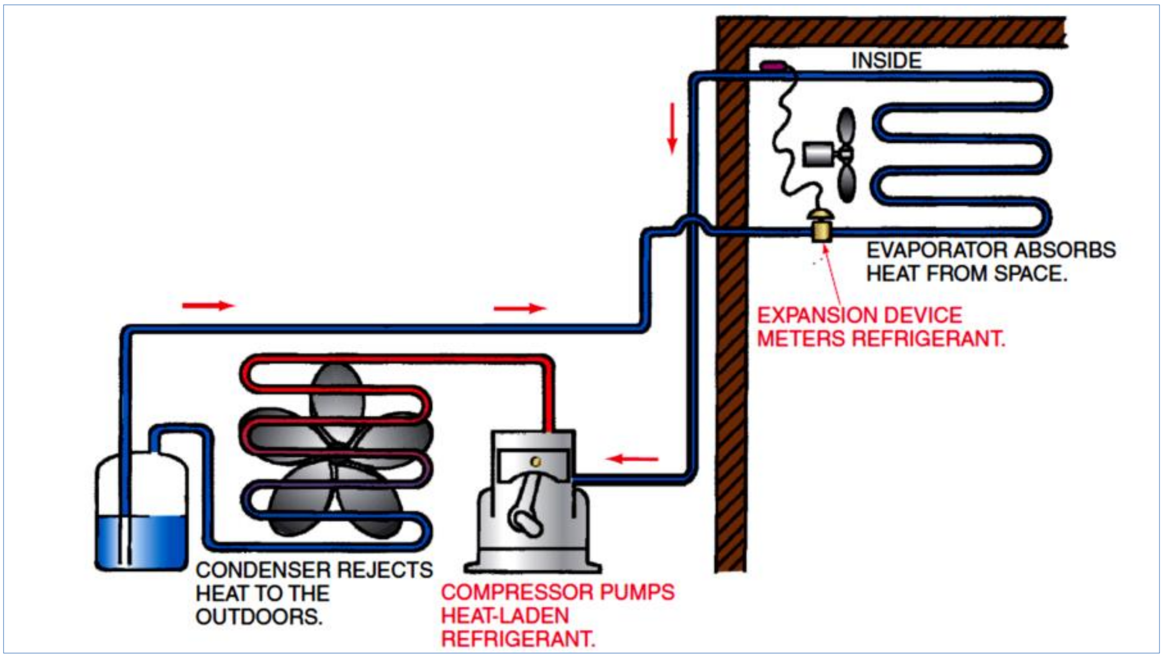


Figure (3.9) show the location of Expansion Valve.

Flow control, or metering, of the refrigerant is accomplished by use of a temperature sensing bulb, filled with a similar gas as in the system that causes the valve to open against the spring pressure in the valve body as the temperature on the bulb increases. As the suction line temperature decreases, so does the pressure in the bulb and therefore on the spring causing the valve to close. An air conditioning system with a TX valve is often more efficient than other designs that do not use one.

3.1.5 Evaporator Coil:

The evaporator coil absorbs heat into the system. When the refrigerant is boiled at a lower temperature than that of the substance to be cooled, it absorbs heat from the substance.

Air Cooling Coils (Evaporator) are available for use with chilled water, and for direct refrigerant evaporation.

Chilled water coils are similar to water heating coils more tube rows are used to allow operation with a lower temperature difference between the water and the air. Chilled water coils are usually 4to8 tube rows deep, and selected to operate with entering chilled water temperature of 5to10C and leaving air temperature of 10 to 15C.

A direct expansion coil uses direct evaporation of a refrigerant to cool the air stream. The Cooling effect may modulated by the injection of refrigerant hot gas at the expansion valve.

Air cooling coils must equipped with a means of draining water condensed from the air stream velocities of over 2 m/s, must eliminator baffles are placed downstream of the cooling coil to prevent water droplet carryover into fans or other downstream equipment.

3.1.6 Condenser & Evaporator Fans:

Fans impart movement to the air stream by using the inertial of the air. The resulting air motion creates inertia of motion, or velocity pressure, and a reaction pressure, in the confining ducts. The duct arrangements at the inlet and the outlet of a fan have a dramatic effect on the fan performance by the efficiency with which the velocity pressure is converted to useful static pressure.

Measurements of fan performance must take into account both static and velocity pressure, or total pressure, across the fan.

The air flow produced by a fan can modulated by varying the fan speed, varying the angle of approach of the air stream with the fan blades, or throttling the air flow with a damper.

The fan speed may be varying by a variable speed motor or a variable speed drive between the motor and the fan. This method normally provides the most efficient use of fan energy.

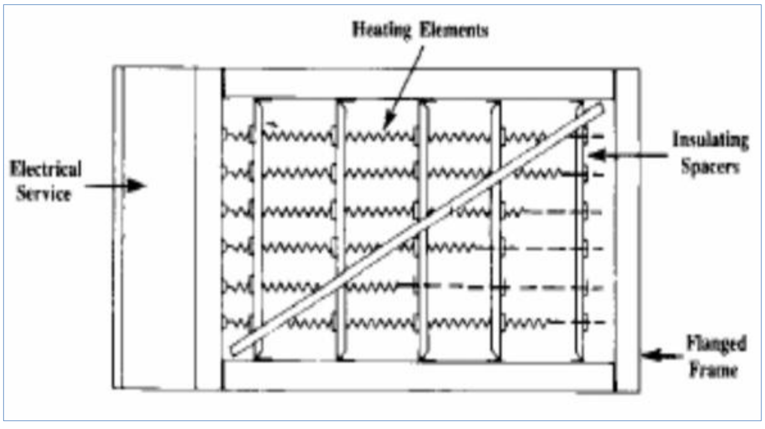
In an axial fan, the angle of the air stream with the fan blades may be varied by rotating the blades. A similar effect may be achieved in a centrifugal fan by radial inlet dampers which impart a spin to the air stream.

Flow throttling dampers create an artificial back pressure to restrict the air flow. Throttling dampers on some types of centrifugal fans can as efficient as radial inlet vanes for regulating fan power input.

3.2 Electrical Component of HVAC System:

3.2.1 Heater Coil:

Electric air heating coils are available with bar resistance elements Figure (3.10) or finned Elements Figure (3.11) To prevent overheating of the elements, electric coils must be protected by a high limit thermostat, and be electrically interlocked to prevent their operation when air flow is stopped



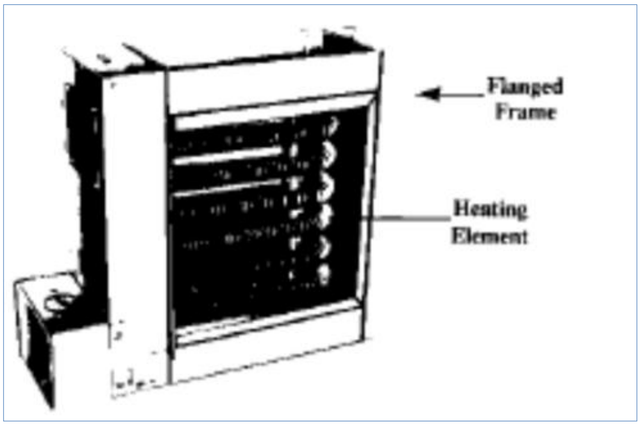


Figure (2.10) show Bar Element electric Coil. Figure (2.11) show Finned Element electric Coil.

3.2.2 Solenoid valve:

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid: in the case of a two-port valve the flow is switched on or off.

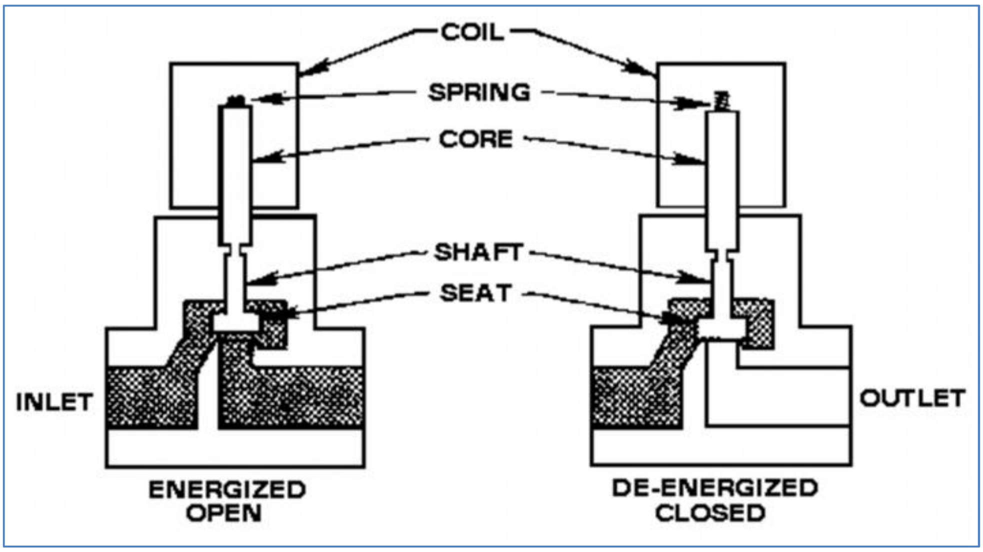


Figure (3.12) show the mechanism of solenoid valve.

3.2.3 Temperature Sensor:

Temperature is the most-measured process variable in industrial automation. Most commonly, a temperature sensor is used to convert temperature value to an electrical value. Temperature Sensors are the key to read temperatures correctly and to control temperature in industrials applications.

A large distinction can be made between temperature sensor types. Sensors differ a lot in properties such as contact-way, temperature range, calibrating method and sensing element. The temperature sensors contain a sensing element enclosed in housings of plastic or metal. With the help of conditioning circuits, the sensor will reflect the change of environmental temperature. In the temperature functional module we developed, we use the LM35 series of temperature sensors.

LM35 is a temperature sensor calibrated to an accuracy of 1 ° C. Its measurement range is from -55 ° C to 150 ° C. The output is linear and each degree Celsius equals 10 mV, thus:

150 ° C = 1500 mV

-55 = -550 mV.

3.2.4 Liquid crystal display:

There are a great many different types of LCD available; we describe them by their various attributes. Color/Monochrome, alphanumeric/graphic.

One of the best things about electronic equipment nowadays are the alphanumeric LCD displays these are simple single, double or 4 line displays for text and numbers. These displays are becoming cheaper and cheaper in cost. The LCD is a great output device and with Bascom so very easy to use. They fit the need for student learning in technology education very nicely.

Connecting an LCD to the microcontroller is not difficult. There are 14 or 16 pins on the LCD as shown below:

1. 0V

2. +5V

3. Contrast

4. RS - register select

5. R/W - read/not write

6. E - Enable

7. D0

8. D1

9. D2

10. D3

11. D4

12. D5

13. D6

14. D7

15. Backlight + (optional)

16. Backlight 0V (optional)

Most LCDs are set up so that they can communicate in parallel with either 4 bits or 8 bits at a time. The faster system is 8 bits as all the data or commands sent to the LCD happen at the same time, with 4 bit operation the data/command is split into 2 parts and each is sent separately. Hence it takes twice as long.

Apart from the 4 data lines another couple of lines are necessary, these are control lines, RS, R/W, E. When using Bascom the R/W line is connected permanently to ground, and the other two lines need to be connected to the micro. The advantage of 4 bit operation is that the LCD uses only 6 I/O lines in total on the micro. At the current time the contrast line can be connected to ground as well.

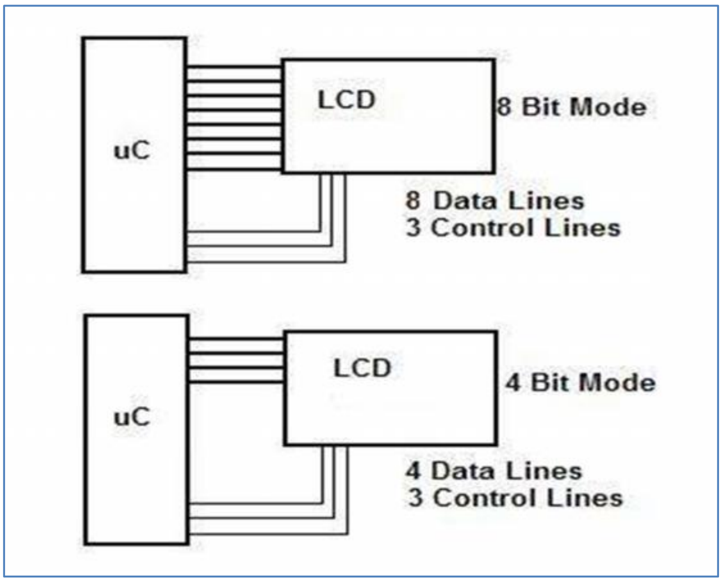


Figure (3.13) show the 8 bit mode & 4 bit mode for LCD.

3.2.5 Light Emitting Diode:

(a)Theory:

As the name indicates, it is a forward-biased P-N junction which emits visible light when energized. Charge carrier recombination takes place when electrons from the N-side cross the junction and recombine with the holes on the P-side.

Now, electrons are in the higher conduction band on the N-side whereas holes are in the lower valence band on the P-side. During recombination, some of the energy difference is given up in the form of heat and light (i.e. photons). For Si and Ge junctions, greater percentage of this energy is given up in the form of heat so that the amount emitted as light is insignificant. But in the case of other semiconductor materials like gallium arsenide (GaAs), gallium phosphide (GaP) and gallium-arsenide-phosphide (GaAsP), a greater percentage of energy released during recombination is given out in the form of light. If the semiconductor material is translucent, light is emitted and the junction becomes a light source i.e. a LED as shown schematically in Figure (3.14). The color of the emitted light depends on the type of material used as given on the next page.

1. GaAs — infrared radiation (invisible).
2. GaP — red or green light.
3. GaAsP — red or yellow (amber) light.

LEDs that emit blue light are also available but red is the most common. LEDs emit no light when reverse-biased. In fact, operating LEDs in reverse direction will quickly destroy them. Figure (3.14) shows a picture of LEDs that emits different colors of light.

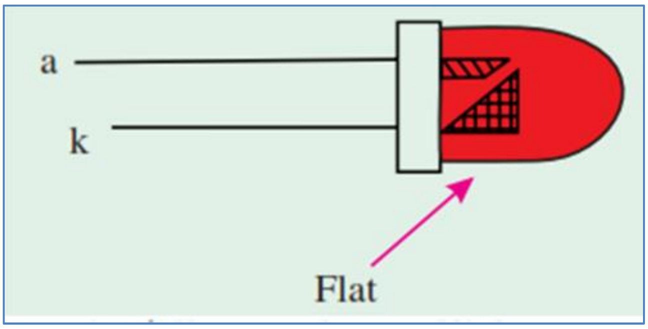


Figure (3.14) show the LED.

(b) Construction:

Broadly speaking, the LED structures can be divided into two categories:

1. Surface-emitting LEDs: These LEDs emit light in a direction perpendicular to the PN junction plane.
2. Edge-emitting LEDs: These LEDs emit light in a direction parallel to the PN junction plane. Figure (3.15) shows the construction of a surface-emit ting LED. As seen from this figure, an N-type layer is grown on a substrate and a P-type layer is deposited on it by diffusion. Since carrier recombination takes place in the P-layer, it is kept upper most. The metal anode connections are made at the outer edges of the P-layer so as to allow more central surface area for the light to escape. LEDs are manufactured with domed lenses in order to lessen the reabsorption problem. A metal (gold) film is applied to the bottom of the substrate for reflecting as much light as possible to the surface of the device and also to provide cathode connection. LEDs are always encased in order to protect their delicate wires.

   Being made of semiconductor material, it is rugged and has a life of more than 10,000 hours.

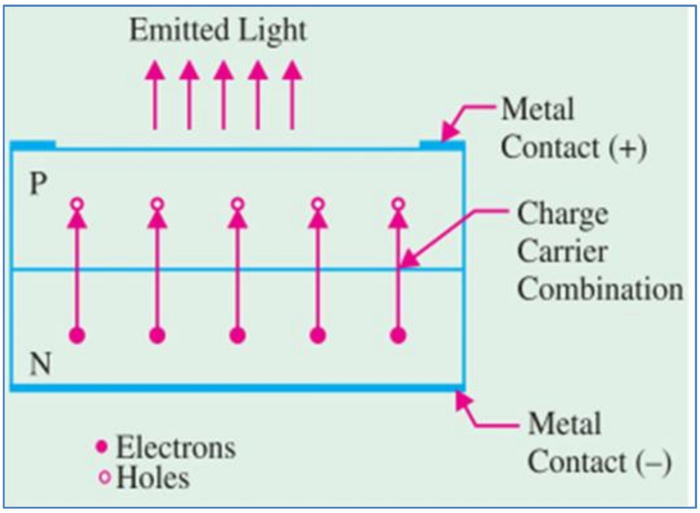


Figure (3.15) shows the construction of a surface-emitting LED.

(c) Working:

The forward voltage across an LED is considerably greater than for a silicon PN junction diode. Typically the maximum forward voltage for LED is between 1.2 V and 3.2 V depending on the device. Reverse breakdown voltage for an LED is of the order of 3 V to 10 V. Figure (3.16) (a) shows a simple circuit to illustrate the working of an LED. The LED emits light in response to a sufficient forward current. The amount of power output translated into light is directly proportional to the forward current as shown in Figure (3.16) (b). It is evident from this figure that greater the forward current, the greater the light output.

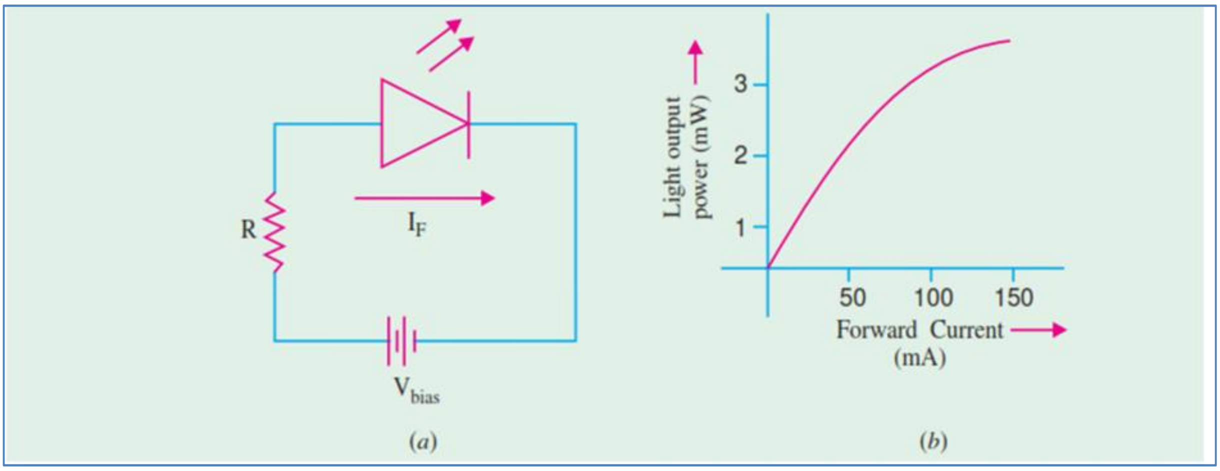


Figure (3.16) (a) shows a simple circuit to illustrate the working of an LED & (b) show the amount of power output translated into light is directly proportional to the forward current.

3.2.6 Pressure switch:

Pressure switches, combining a diaphragm or other pressure measuring means with a precision snap switch, can provide precise single-point pressure sensing. Alternatively, simple electronic switches may be combined with electrical sensors to construct a pressure switch with an adjustable set point and hysteresis.

A pressure switches are used for regulating, monitoring and alarm systems in industry. Pressure switches are recommended for gaseous media (also water, but only when mounted directly on the pipe - do not use capillary tube mounting). The pressure switches are fitted with a single pole switch change over (SPDT). The position of the switch depends on the setting of the pressure control and the pressure in the connector.

3.2.7 Push button switches SPST Switches:

A SPST is short form Single pole input/ Single pole output and this type of switch is a set of contacts inside the switch opens or closes the circuit. The contacts carry the current load of the circuit when closed. Switch contacts are spring loaded. Closing the circuit requires overcoming spring pressure Circuit is opened by spring Switch is (NO).

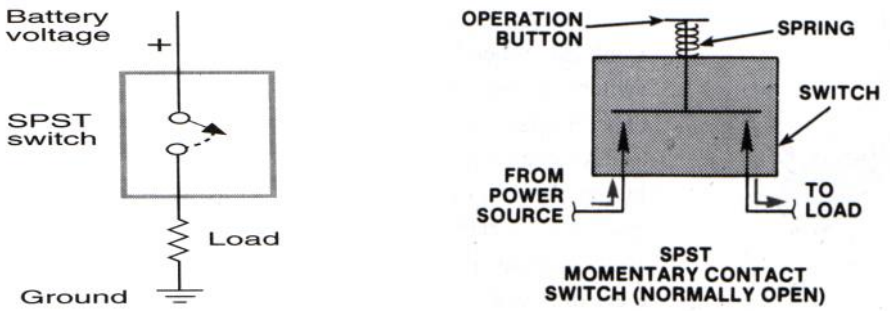


Figure (3.17) shows the construction of a SPDT Switch and mechanism of it.

3.2.8 Microcontroller Atmega 325:

ATmega325 is an 8-bit high performance microcontroller. It is a less power consuming device. The Atmel's Atmega series of microcontrollers are very popular due to the large number f peripherals built in them. They have features such as 10-bit A/D converters, UART/USART, and much more and due to that reason they become useful for a large number of applications and external hardware is reduced as these are built-in.

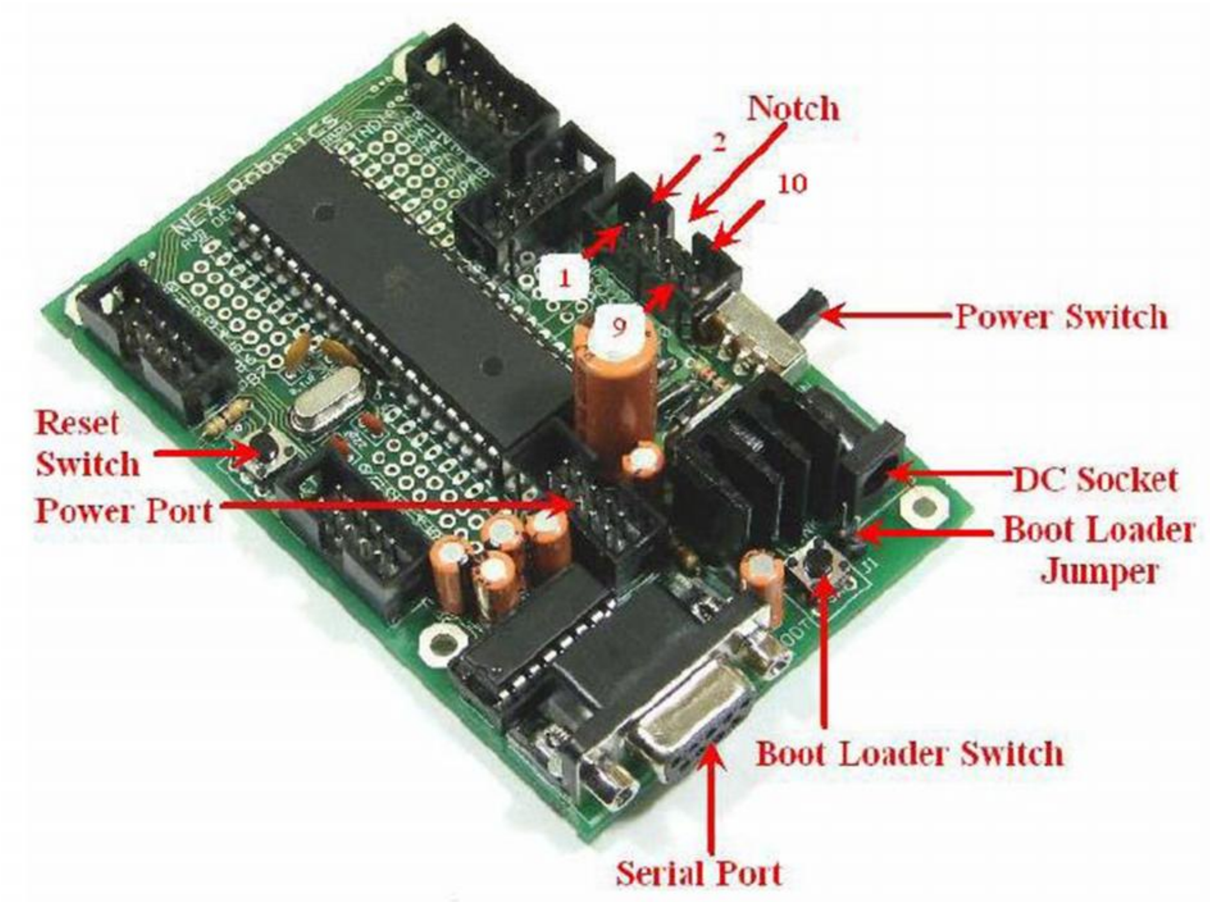


Figure (3.18) show ATmega325 Development Board

Features

• High Performance, Low Power Atmel® AVR® 8-Bit Microcontroller

• Advanced RISC Architecture

– 130 Powerful Instructions – Most Single Clock Cycle Execution

– 32 x 8 General Purpose Working Registers

– Fully Static Operation

– Up to 16MIPS Throughput at 16MHz

– On-Chip 2-cycle Multiplier

• High Endurance Non-volatile Memory Segments

– In-System Self-programmable Flash Program Memory

• 32KBytes (ATmega325/ATmega3250)

–EEPROM

• 1Kbytes (ATmega325/ATmega3250)

– Internal SRAM

• 2Kbytes (ATmega325/ATmega3250)

– Write/Erase Cycles: 10,000 Flash/ 100,000 EEPROM

– Data retention: 20 years at 85°C/100 years at 25°C

– Optional Boot Code Section with Independent Lock Bits

• In-System Programming by On-chip Boot Program

• True Read-While-Write Operation

– Programming Lock for Software Security

• Atmel®QTouch® library support

– Capacitive touch buttons, sliders and wheels

– QTouch and QMatrix®acquisition

– Up to 64 sense channels

• JTAG (IEEE std. 1149.1 compliant) Interface

– Boundary-scan Capabilities According to the JTAG Standard

– Extensive On-chip Debug Support

– Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface

• Peripheral Features

– Two 8-bit Timer/Counters with Separate Prescaler and Compare Mode

– One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode

– Real Time Counter with Separate Oscillator

– Four PWM Channels

– 8-channel, 10-bit ADC

– Programmable Serial USART

– Master/Slave SPI Serial Interface

– Universal Serial Interface with Start Condition Detector

– Programmable Watchdog Timer with Separate On-chip Oscillator

– On-chip Analog Comparator

– Interrupt and Wake-up on Pin Change

• Special Microcontroller Features

– Power-on Reset and Programmable Brown-out Detection

– Internal Calibrated Oscillator

– External and Internal Interrupt Sources

– Five Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, and Standby

• I/O and Packages

– 53/68 Programmable I/O Lines

– 64-lead TQFP, 64-pad QFN/MLF, and 100-lead TQFP

• Speed Grade:

– ATmega325V/ATmega3250V/ATmega645V/ATmega6450V:

• 0 - 4MHz @ 1.8 - 5.5V; 0 - 8MHz @ 2.7 - 5.5V

– Atmel ATmega325/3250/645/6450:

• 0 - 8MHz @ 2.7 - 5.5V; 0 - 16MHz @ 4.5 - 5.5V

• Temperature range:

–-40°C to 85°C IndustrSial

• Ultra-Low Power Consumption

– Active Mode:

1MHz, 1.8V: 350µA

32 kHz, 1.8V: 20µA (including Oscillator)

– Power-down Mode:

100 nA at 1.8V

Pin Configurations of ATmega32:

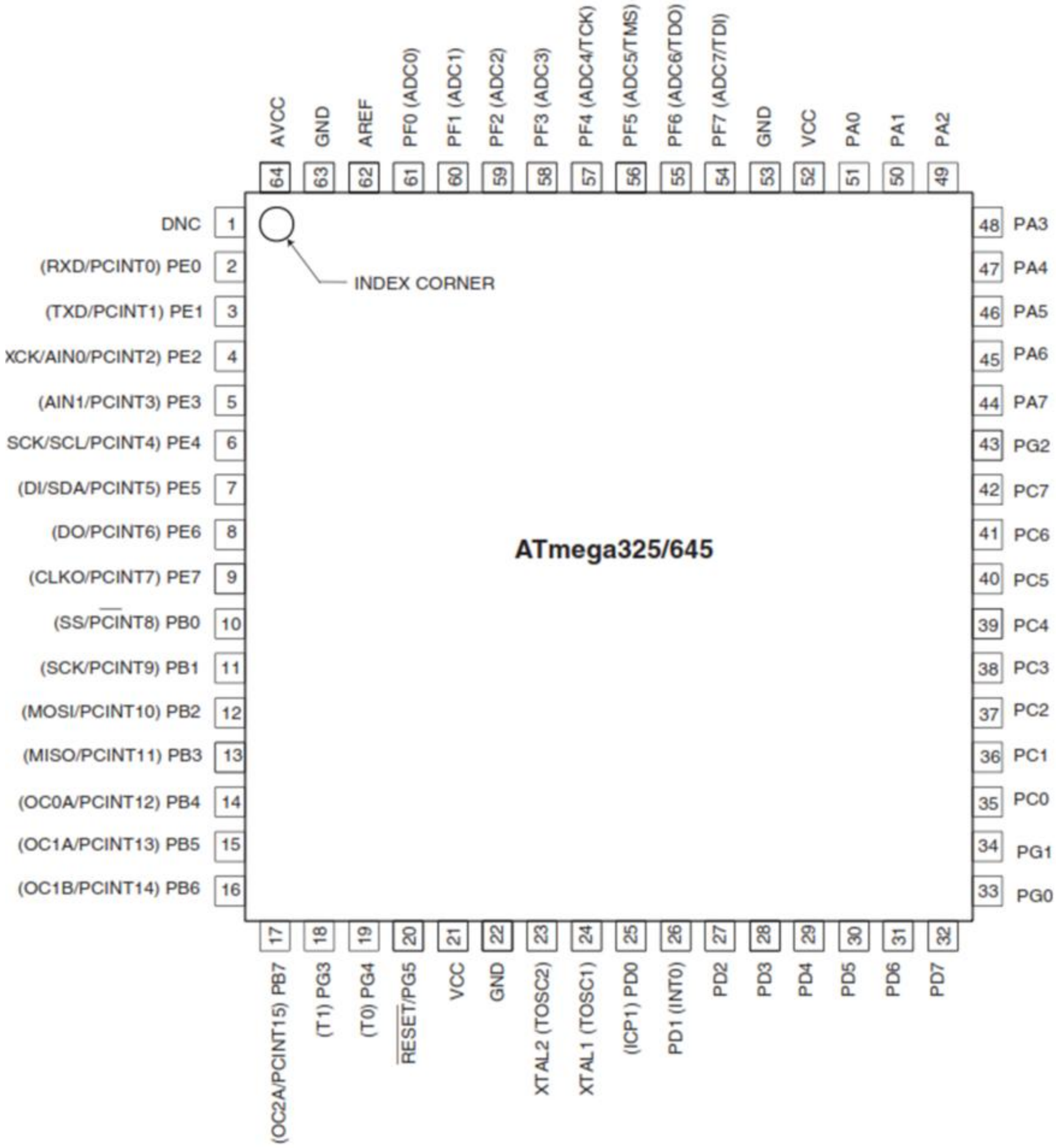


Figure (3.19) show Pin Configuration of ATmega325.

Pin Descriptions:

The following section describes the I/O-pin special functions.

Vcc: Digital supply voltage.

GND: Ground.

Port A (PA7..PA0):

Port A is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port A pins that are externally pulled low will source current if the pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B (PB7..PB0) :

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port C (PC7..PC0):

Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port D (PD7..PD0):

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated.

The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port E (PE7..PE0):

Port E is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port E output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port E pins that are externally pulled low will source current if the pull-up resistors are activated. The Port E pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port F (PF7..PF0):

Port F serves as the analog inputs to the A/D Converter. Port F also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port F output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port F pins that are externally pulled low will source current if the pull-up resistors are activated. The Port F pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PF7 (TDI), PF5 (TMS), and PF4 (TCK) will be activated even if a reset occurs.

Port F also serves the functions of the JTAG interface.

Port F (PF7..PF0):

Port G is a 6-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port G output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port G pins that are externally pulled low will source current if the pull-up resistors are activated. The Port G pins are tri-stated when a reset condition becomes active, even if the clock is not running.

RESET:

Reset Input. A reset is generated if a low level occurs on this pin for longer than the minimum pulse length, even if the clock is not running. Shorter pulses will generate a reset it is not guaranteed.

XTAL1:
It is the input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2:
It is the output coming from the inverting Oscillator amplifier.

AVCC:
It is the supply voltage pin for Port A and for the A/D Converter. Even if the ADC is no used it must be externally connected to VCC. If the ADC is used, it is connected to VCC with the help of a low-pass filter.

AREF:

It is the analog reference pin for the ADC.

3.2.9 Potentiometer:

The potentiometer is an electrical device comprising a resistor with a sliding third contact, often termed a wiper, which allows the voltage to be varied depending upon where the slider is positioned along the length of the resistor.

Potentiometers are found in many electrical and electronic applications and in many different forms, sizes and power ratings. For instance, in a relatively high power application a wire wound potentiometer may be used to provide a variable D.C. (or a.c.) power supply delivering many amperes at some voltage less than the supply voltage. In an electronic system a low power rated carbon track potentiometer may be used to preset the voltage on a circuit board to achieve the desired level of response.

in both examples, the principle of operation is essentially the same. Manual adjustment of the wiper along the length of the fixed resistance produces a variable voltage at the wiper. The magnitude of this output voltage is directly proportional to its relative position along the length of the resistor.

If the potentiometer wiper is appropriately connected to a moving system then any movement in that system will cause the wiper to move and so change the output voltage. This signal provides a direct measurement of position or change in position. Hence, although still a potentiometer, it is of use as a sensor for measuring linear displacement.

A potentiometer circuit is shown schematically in Figure

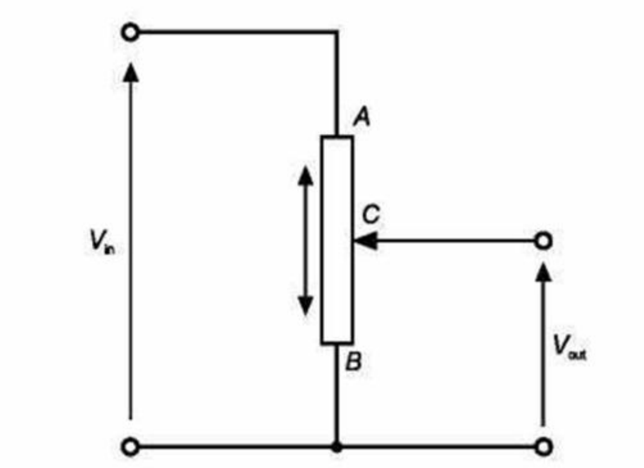


Figure (3.20) show Potentiometer.

The output voltage is governed by the position of the wiper (C) which may lie anywhere between the two ends, A and B, of the resistance. For the general case the output voltage is given by the expression,

$$V_{out} = V_{in} \frac{CB}{AB}$$

where:

CB is the linear distance (or angular rotation) from B to C;

AB is the maximum linear distance (or angular rotation) from B to A.

Hence when the potentiometer wiper is in position B the output voltage will be zero and when in position A will be maximum, the full supply voltage (Vin). In any intermediate position the voltage at the wiper will be some value between 0 and Vin as given by the above potentiometer equation.

If the resistance is linear throughout its length then the output voltage will also be linear and directly proportional to the wiper position along the length of the resistance. In the SIS, the wipers of both the linear and rotary potentiometers connect to the Linear Assembly such that any movement of the assembly causes the output voltage to change in direct proportion. This experiment investigates the use of linear and rotary potentiometers for measuring displacement.

3.2.10 Resistor:

Resistor is electrical or electronic components which resist the flow of current cross the resistor device. The resistance to current flow results in a voltage drop a cross the resistor device. Resistors are used extensively throughout electrical and electronic circuits.

Resistor devices may provide may provide a fixed, variable, or adjustable value of resistance. Adjustable resistors are refers to ostats, or iometers. Resistor value is expressed in Ohms, the electric resistance unit.

Resistors are incorporated within a electrical or electronic circuit create a known voltage drop or current to voltage relationship. If the electrical current in a circuit is known (current is measured in amperes), then a resistor can be used to create a known potential difference (voltage difference) proportional to that current. Conversely, points in a circuit are known, a resistor can be used to create a known current proportional to that difference.

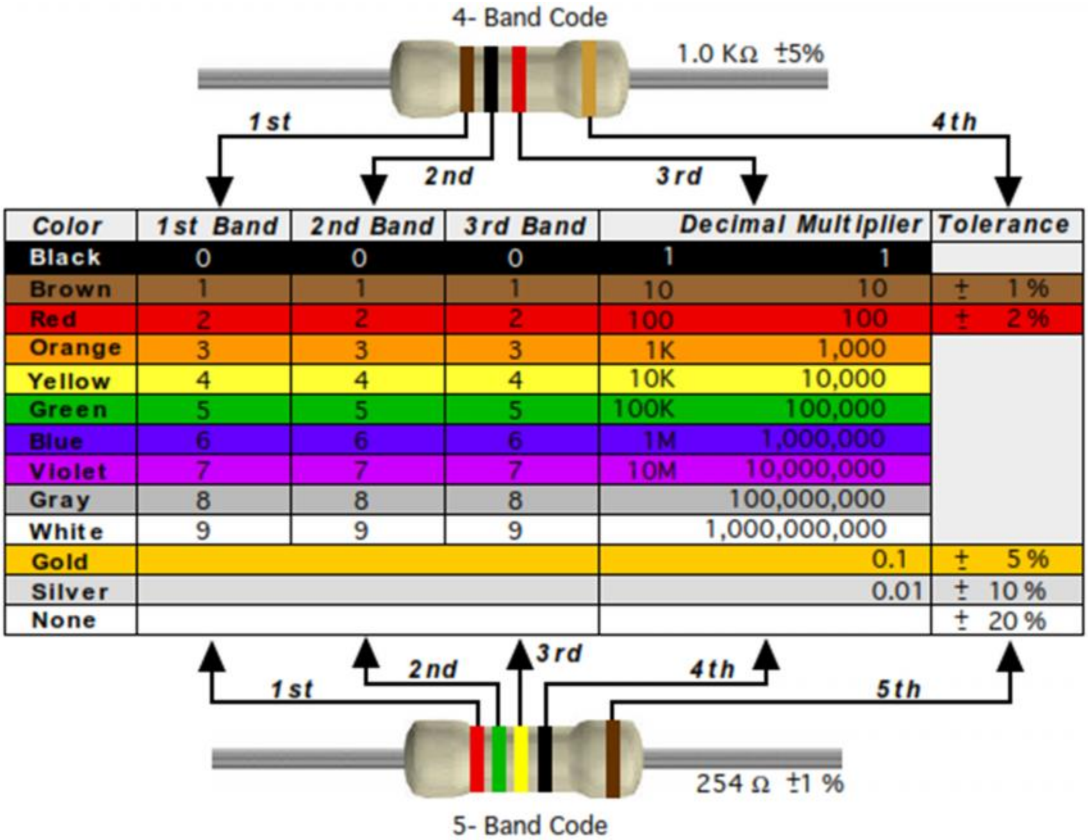
An attenuator is a network of two or more resistors (a voltage divider). A line terminator is a resistor at the end of a transmission line or daisy chain bus, designed to match impedance and minimize reflections of the electronic signal.

Resistors can be broadly of two types:

1. Fixed Resistors:

   Carbon Film (5%, 10% tolerance) and Metal Film Resistors (1%, 2% tolerances) and wire wound resistors. A fixed resistor is one for which the value of its resistance is specified and cannot be varied in general.

   The resistance value is displayed using the color code guide as shown below picture.



Color	1st Band	2nd Band	3rd Band	Decimal Multiplier		Tolerance
Black	0	0	0	1	1	
Brown	1	1	1	10	10	± 1 %
Red	2	2	2	100	100	± 2 %
Orange	3	3	3	1K	1,000	
Yellow	4	4	4	10K	10,000	
Green	5	5	5	100K	100,000	
Blue	6	6	6	1M	1,000,000	
Violet	7	7	7	10M	10,000,000	
Gray	8	8	8		100,000,000	
White	9	9	9		1,000,000,000	
Gold					0.1	± 5 %
Silver					0.01	± 10 %
None						± 20 %

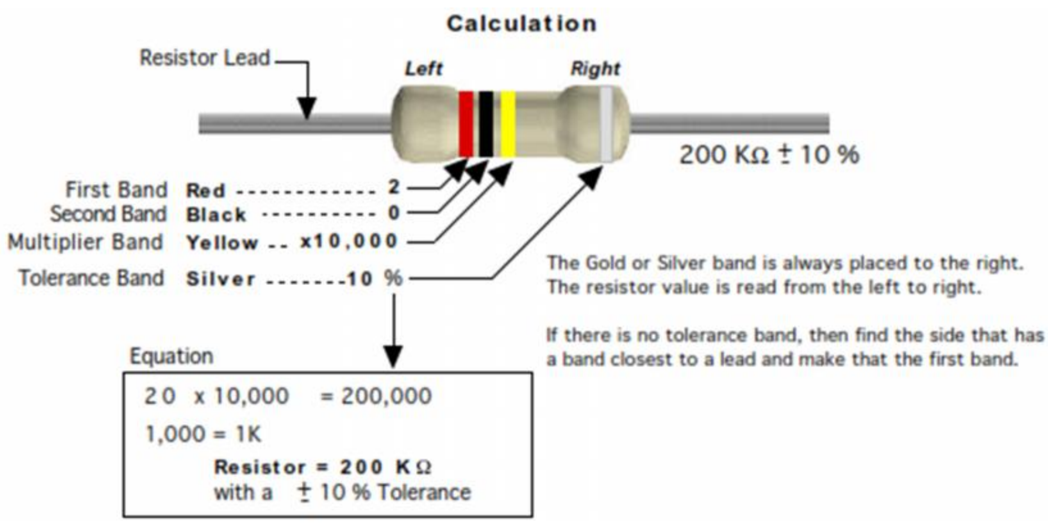


Figure (3.21) show the method of calculation the value of resistance.

2. Variable Resistors:

   There are two general ways in which variable resistors are used. One is the variable resistor whose value is easily changed, like the volume adjustment of Radio. The other is semi-fixed resistor that is not meant to be adjusted by anyone but a technician. It is used to adjust the operating condition of the circuit by the technician. Semi-fixed resistors are used to compensate for the inaccuracies of the resistors, and to fine-tune a circuit. The rotation angle of the variable resistor is usually about 300 degrees. Some variable resistors must be turned many times (multi-turn Pot) to use the whole range of resistance they offer. This allows for very precise adjustments of their value. These are called "Potentiometers" or "Trimmer Potentiometers" or "presets". The four resistors at the center are the semi-fixed type. The two resistors on the left are the trimmer potentiometers.

Chapter Four

Software Design of HVAC System

4.1 Introduction:

Basic object of this thesis is to control Heaters, compressors & fans to maintain constant temperature in an environment of Building. For this we are using ATMEGA325 microcontroller as the main controller and LM35 for Temperature Sensor. One 20X4 LCD is attached with the microcontroller to display the Set Temperature Value and Present Temperature Value. LCD will also to display the status of Compressors, Fans & Heaters. For Heaters, Compressors & Fans we are using a quantity of Relays to control 230VAC coil contactors of each. The following Figure (4.1) illustrated the controller of HVAC system.

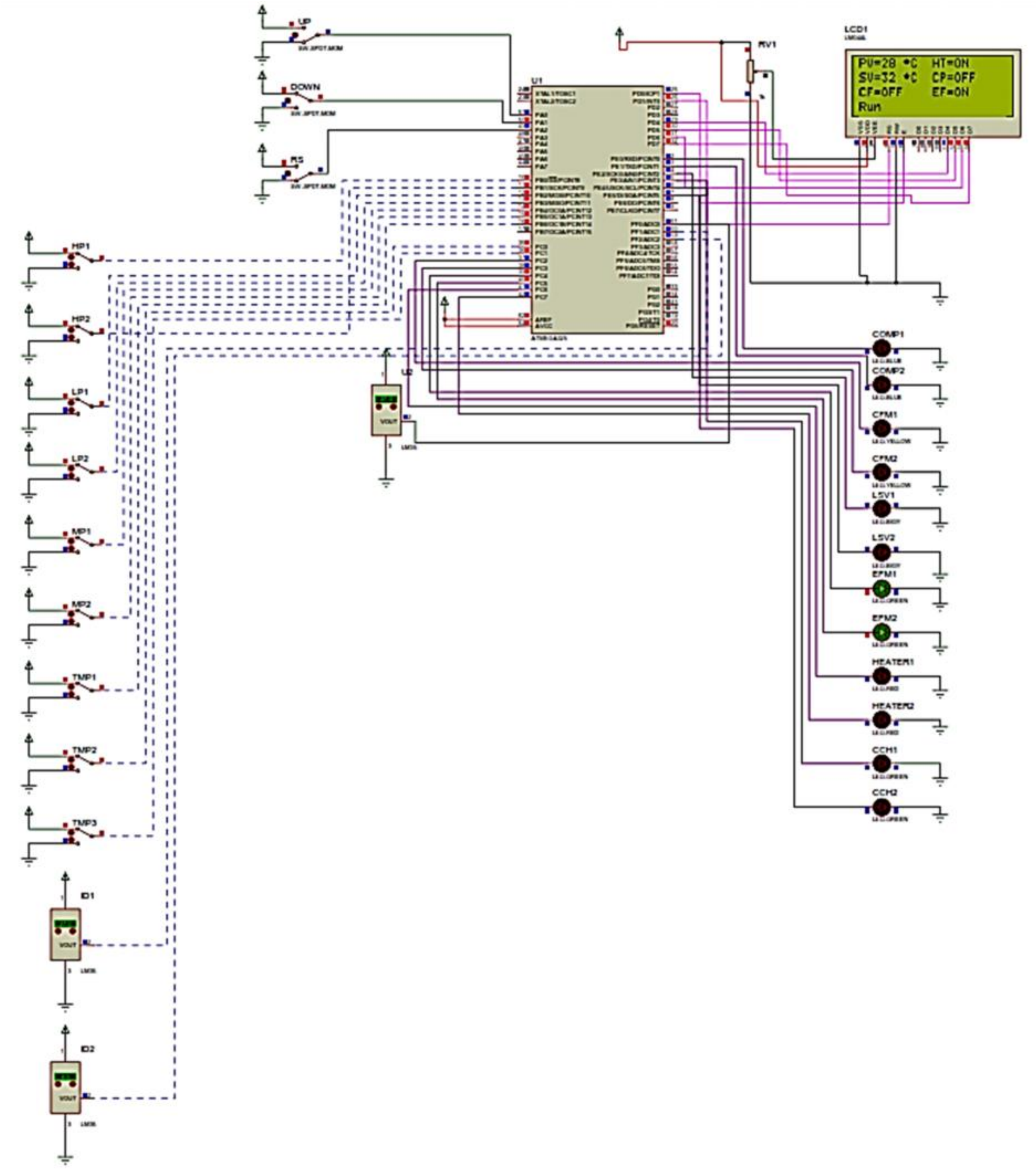


Figure (4.1) illustrated the controller of HVAC System.

3.2 Control System Block Diagram:

The block diagram system is illustrated in Figure (4.2). The two input switches to insert the desire temperature for Building ,one input switch to reset microcontroller when happen alarm, one temperature sensor to give actual Building temperature called present value “PV”, two temperature sensors as protection HVAC system and a group of several types input switches used as also protection the HVAC system . The difference between the present value &

set value temperatures allows the controller to control of the compressor, Heaters & Fans to the desired set point temperature. In addition to there is several actuators on HVAC system as shown below block diagram:

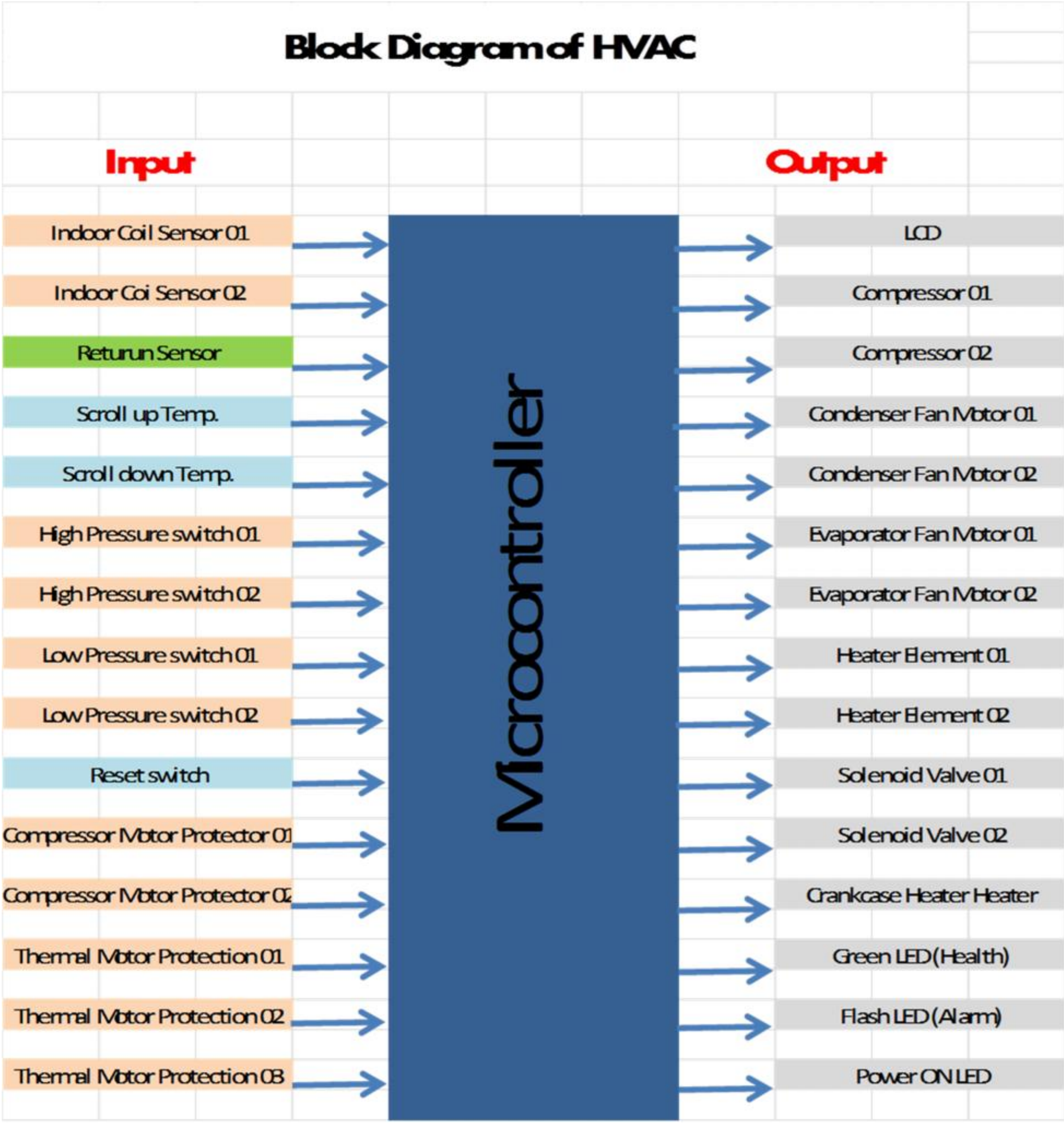


Figure (4.2) illustrated the Block Diagram of HVAC System.

3.3 Flow Chart:

The flowchart of the Control Program is beginning in **Figure (3.3)**.

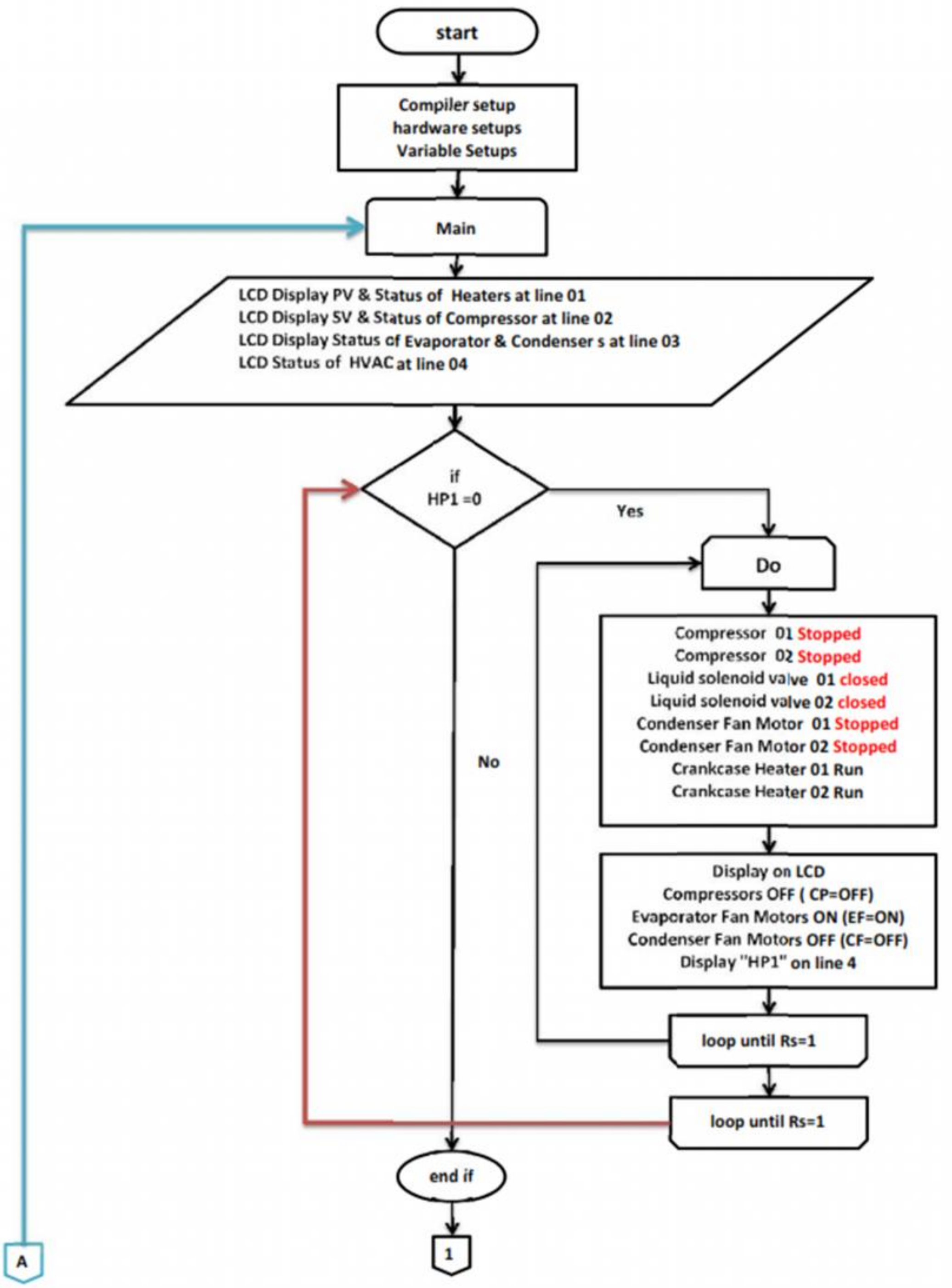


Figure (4.3) the flow chart illustrated the Configuration of Microcontroller, status of HVAC on LCD & Sequence of High pressure 01 Alarm.

Whenever the system is switched ON, LCD will display “PV” (for Present Temperature Value) and status of Heater Element (as “HT”) on line01, “SV” (for SET Temperature Value) and status of Compressors (as “CP”) on line02, status of Evaporator (as “EF”) and Condenser Fans (as “CF”) on line03 & status of all equipment on line04.

We have interfaced three switches with the microcontroller. Now to change the “SV”, we have used two switches as UP switch and DWON switch. Now on pressing UP switch, value of SV will increase and DOWN switch, value of SV will decrease.

To do the main function of the project, i.e. controlling of Compressors and Heaters, we use three compare functions in our software. To overcome the problem of frequently ON/OFF of Heaters and Compressors, we assume hysteresis of±5℃, i.e. Heaters or Compressors status will be changed if PV is out of ±5°C. So, if PV is greater than ±5°C of SV then Compressors will be on to cool down the environment and if PV is bellow ±5°C of SV then Heater will be ON to increase the temperature of the environment. And when PV is within ±5°C of SV, Heaters and Compressors will be OFF. This is to note that in a moment either Heaters or Compressors will be ON.

When the HP1 alarm is turned on, the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan ON until pressed Reset switch (as “RS”), then the microcontroller will check a gain the HP1 alarm is found or not, if pressed Reset switch again & HP1 alarm is not found, then the controller will go to main program.

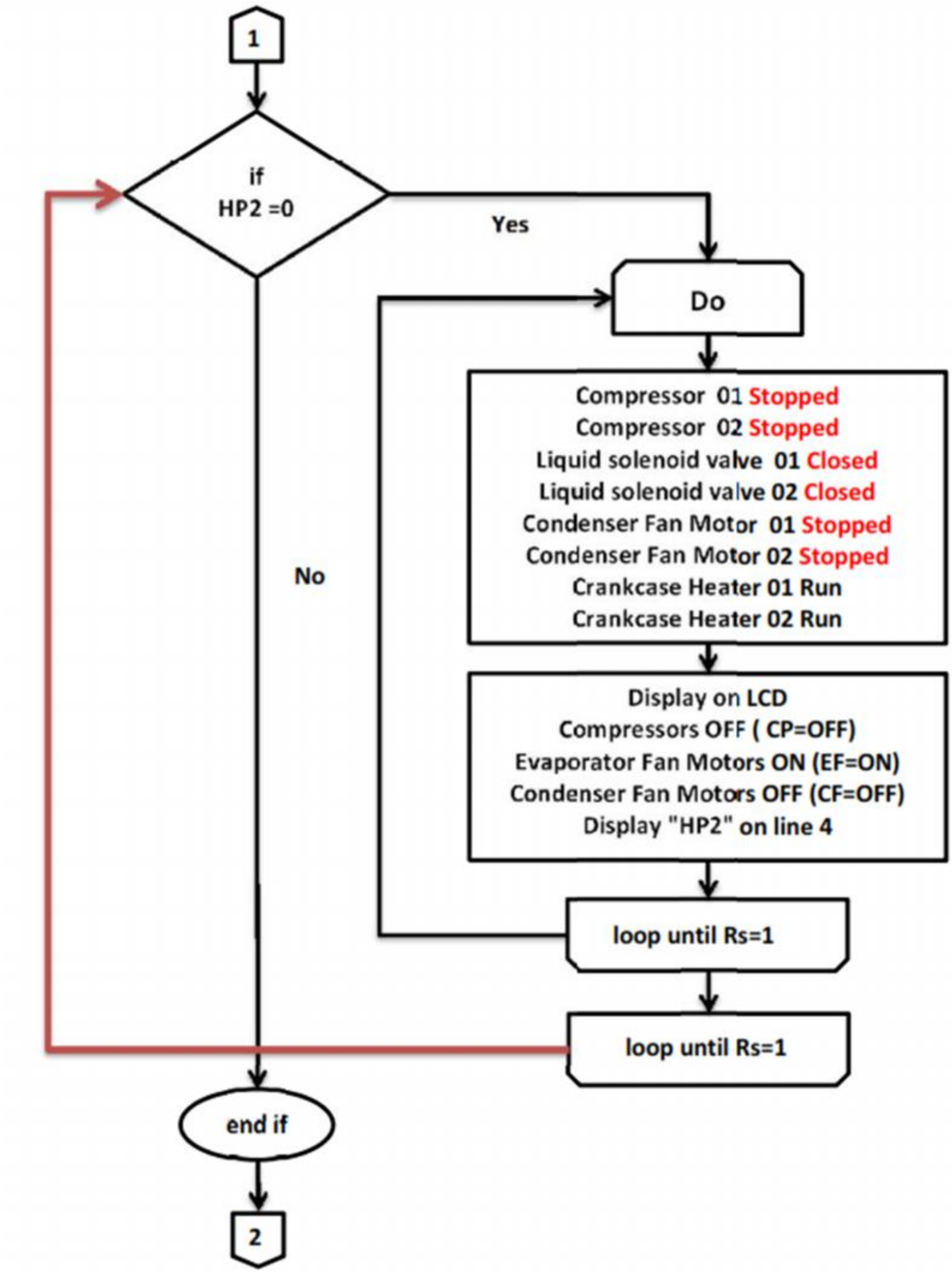


Figure (4.4) The Sequence of High pressure 02 Alarm.

When the HP2 alarm is turned on, the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan ON until pressed Reset switch (as “RS”), then the microcontroller will check a gain the HP2 alarm is found or not, if pressed Reset switch again & HP2 alarm is not found, then the controller will go to main program.

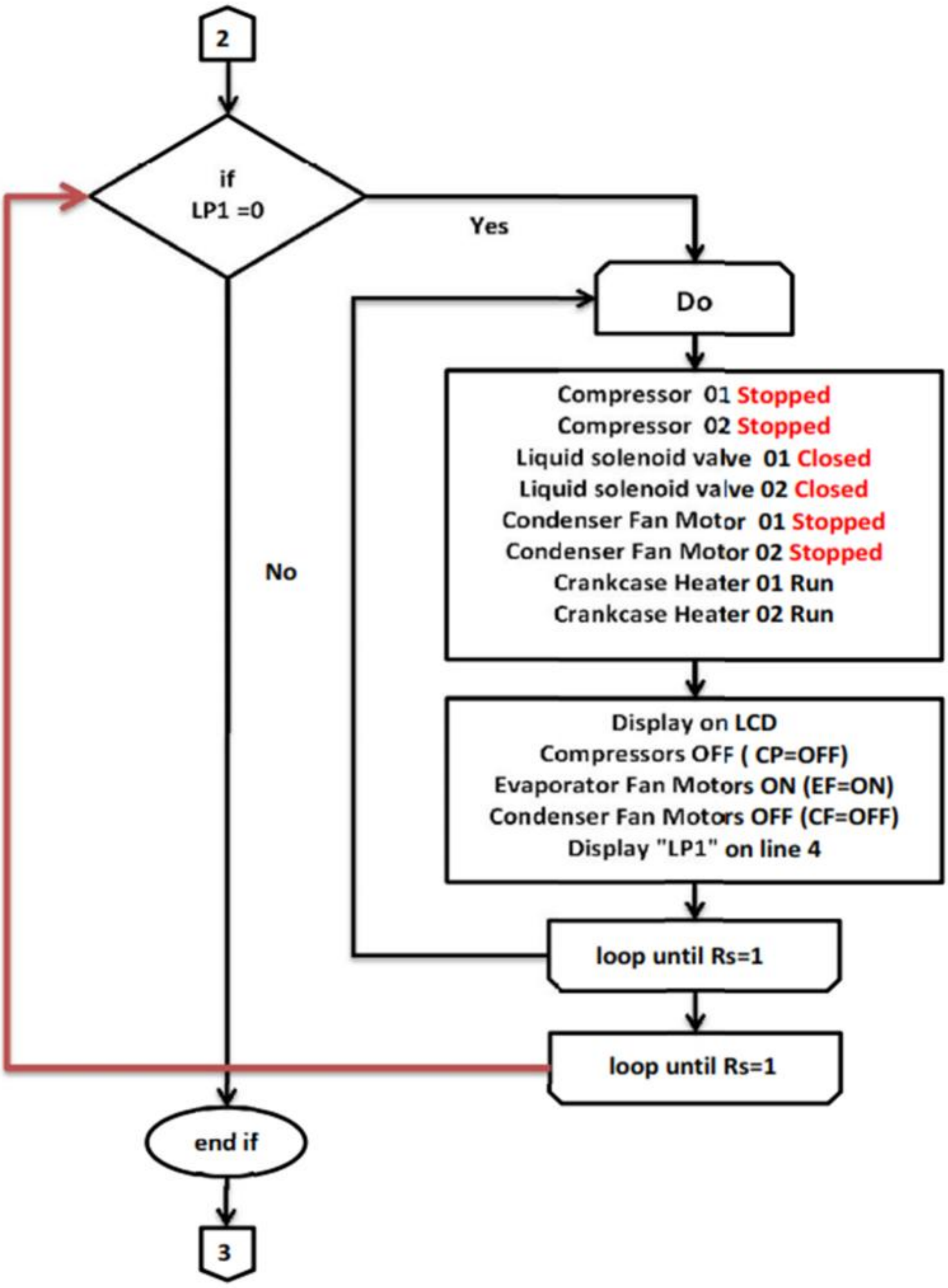


Figure (4.5) The Sequence of Low pressure 01 Alarm.

When the LP1 alarm is turned on, the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan ON until pressed Reset switch (as “RS”), then the microcontroller will check a gain the LP1 alarm is found or not, if pressed Reset switch again & LP1 alarm is not found, then the controller will go to main program.

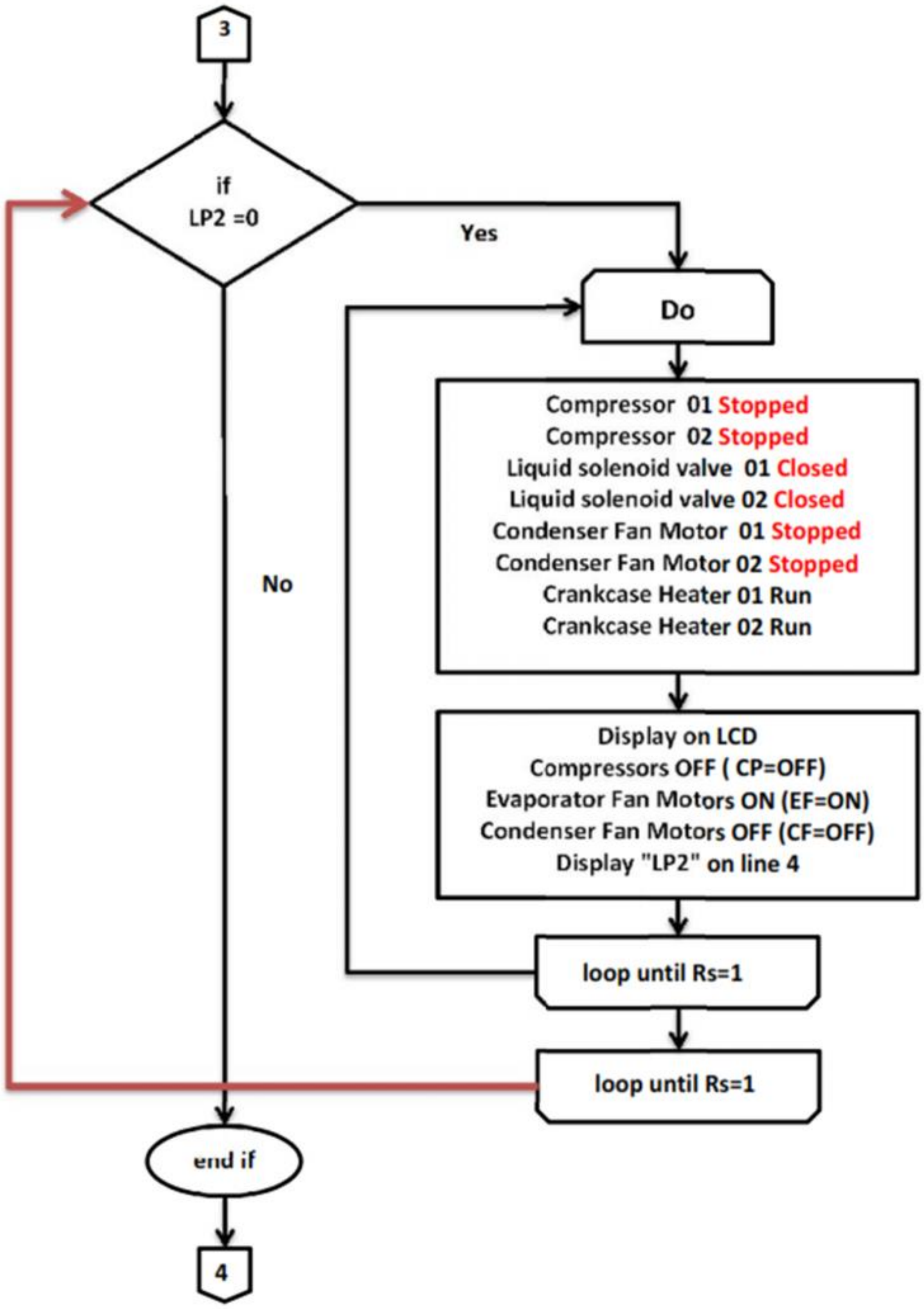


Figure (4.6) The Sequence of Low pressure 02 Alarm.

When the LP2 alarm is turned on, the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan ON until pressed Reset switch (as “RS”), then the microcontroller will check a gain the LP2 alarm is found or not, if pressed Reset switch again & LP2 alarm is not found, then the controller will go to main program.

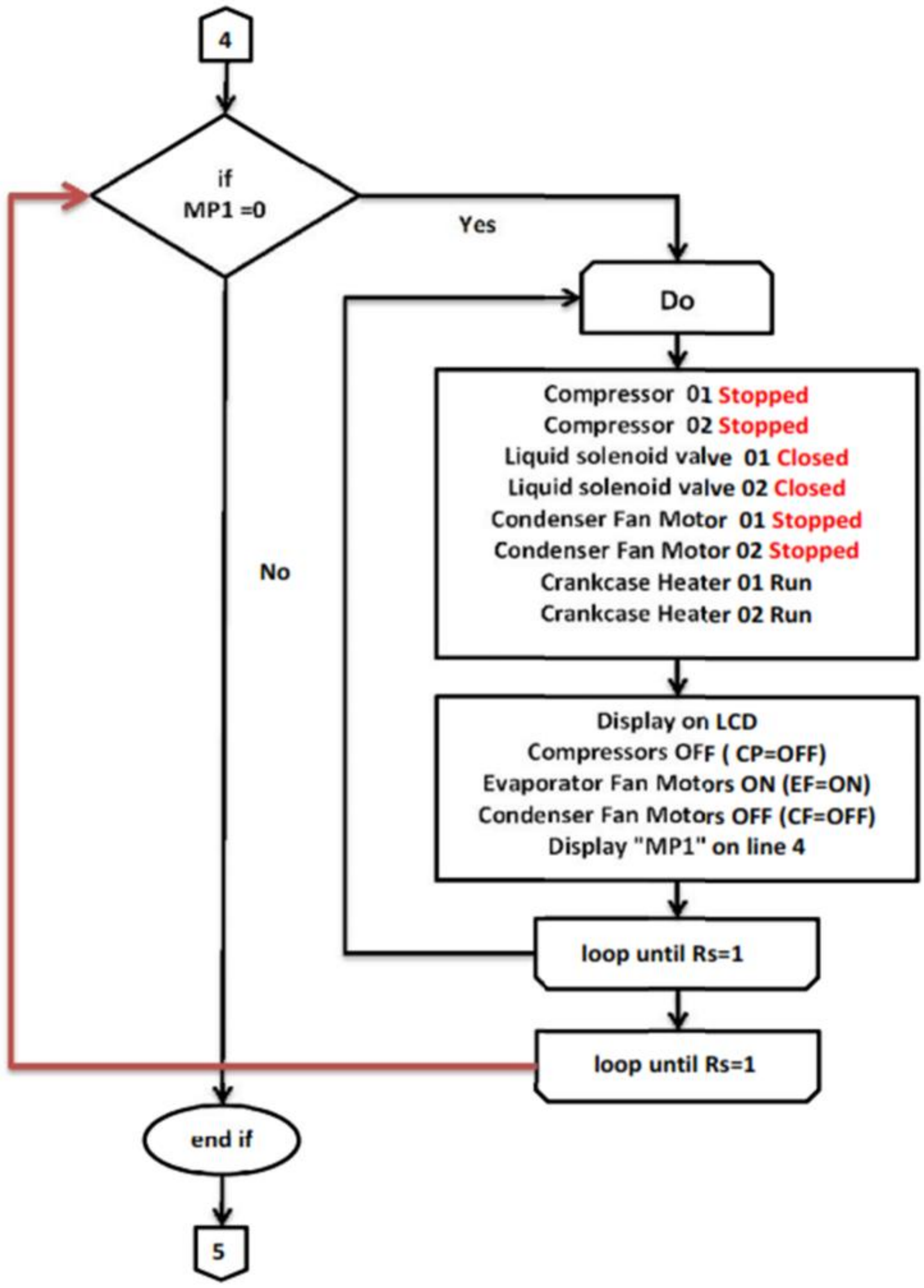


Figure (4.7) The Sequence of Motor Protection 01 Alarm.

When the MP1 alarm is turned on, the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan ON until pressed Reset switch (as “RS”), then the microcontroller will check a gain the MP1 alarm is found or not, if pressed Reset switch again & MP1 alarm is not found, then the controller will go to main program.

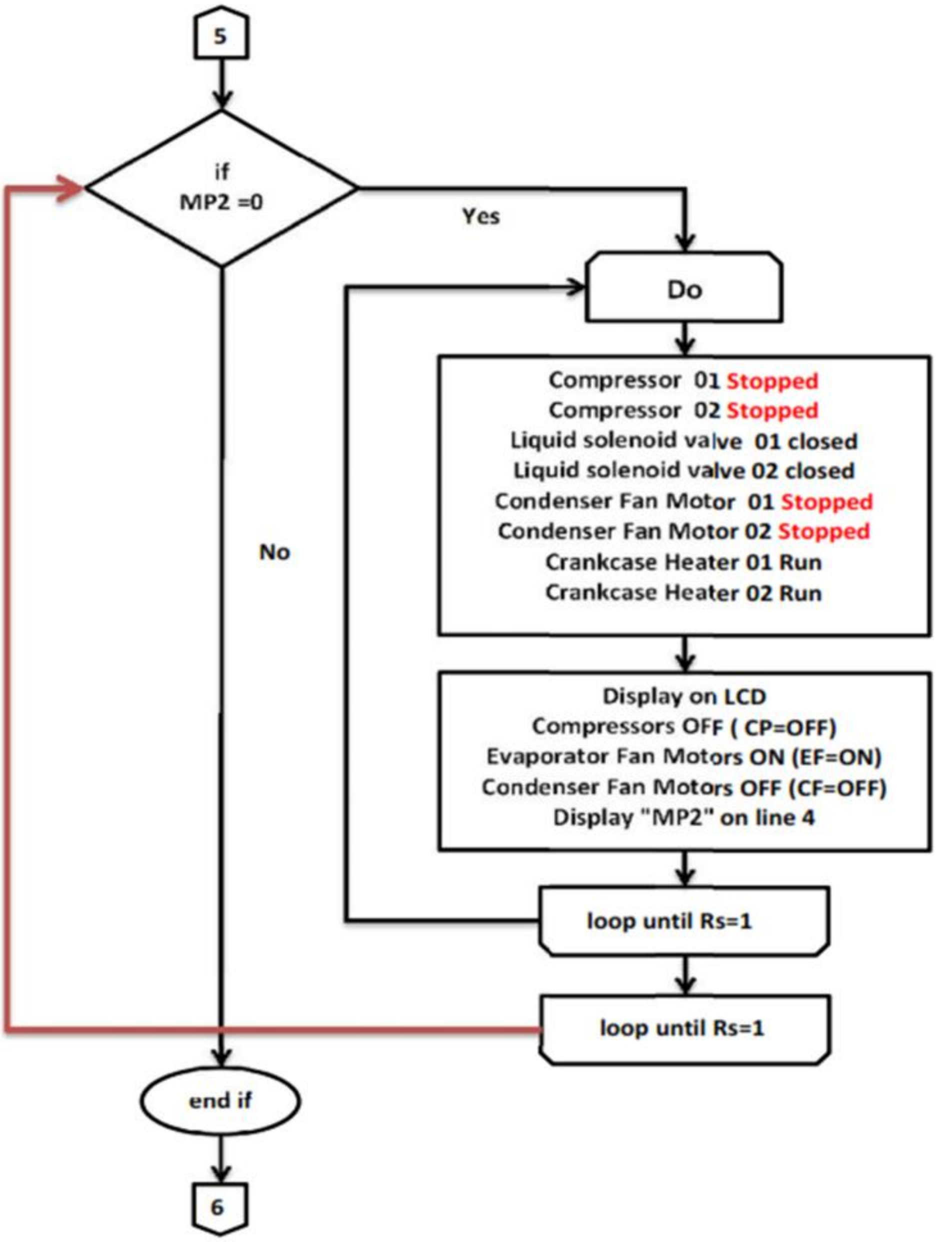


Figure (4.8) The Sequence of Motor Protection 02 Alarm.

When the MP2 alarm is turned on, the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan ON until pressed Reset switch (as “RS”), then the microcontroller will check a gain the MP2 alarm is found or not, if pressed Reset switch again & MP2 alarm is not found, then the controller will go to main program.

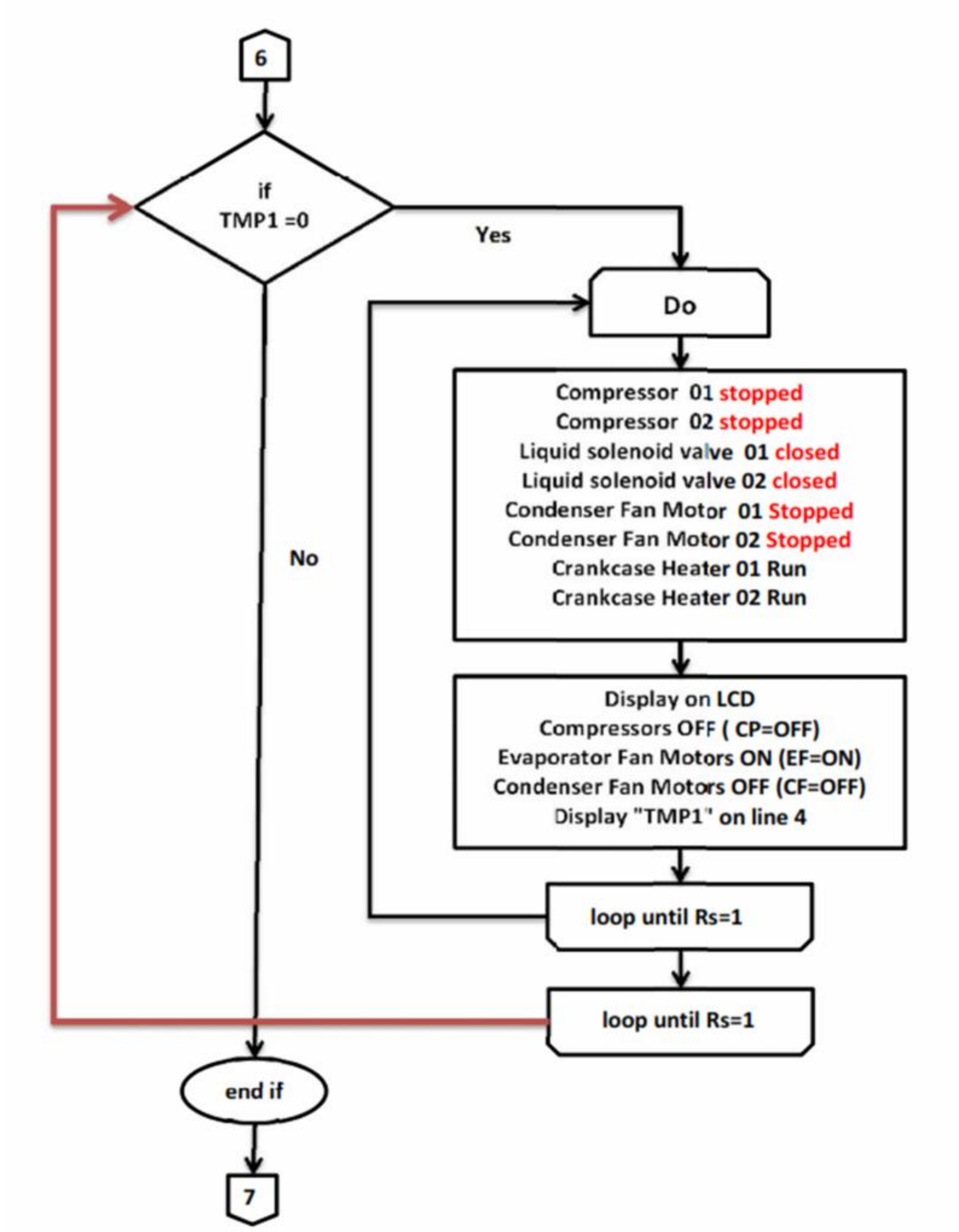


Figure (4.9) The Sequence of Thermal Motor Protection 01 Alarm.

When the TMP1 alarm is turned on, the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan ON until pressed Reset switch (as “RS”), then the microcontroller will check a gain the TMP1 alarm is found or not, if pressed Reset switch again & TMP1 alarm is not found, then the controller will go to main program.

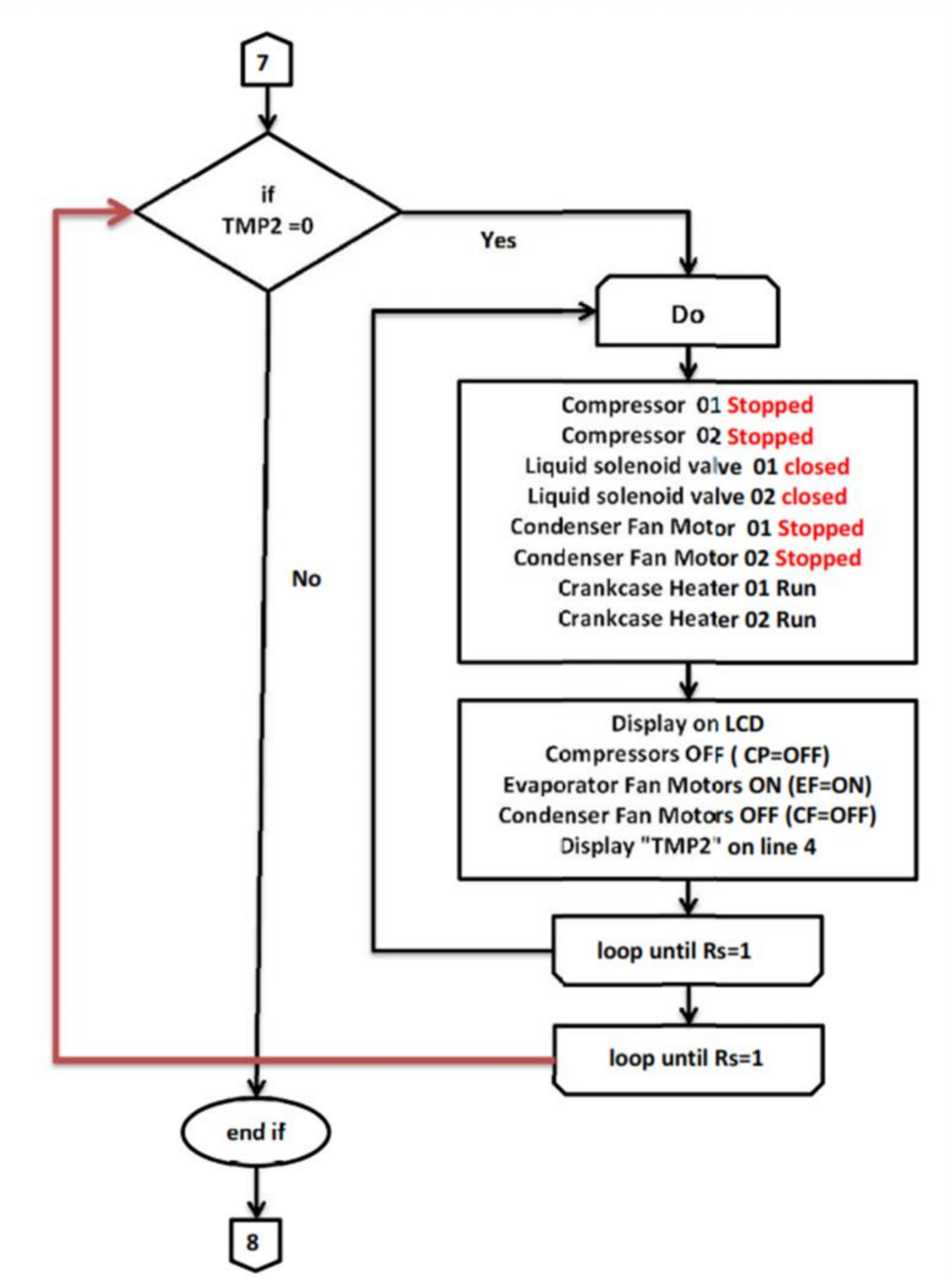


Figure (4.10) The Sequence of Thermal Motor Protection 02 Alarm.

When the TMP2 alarm is turned on, the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan ON until pressed Reset switch (as “RS”), then the microcontroller will check a gain the TMP2 alarm is found or not, if pressed Reset switch again & TMP2 alarm is not found, then the controller will go to main program.

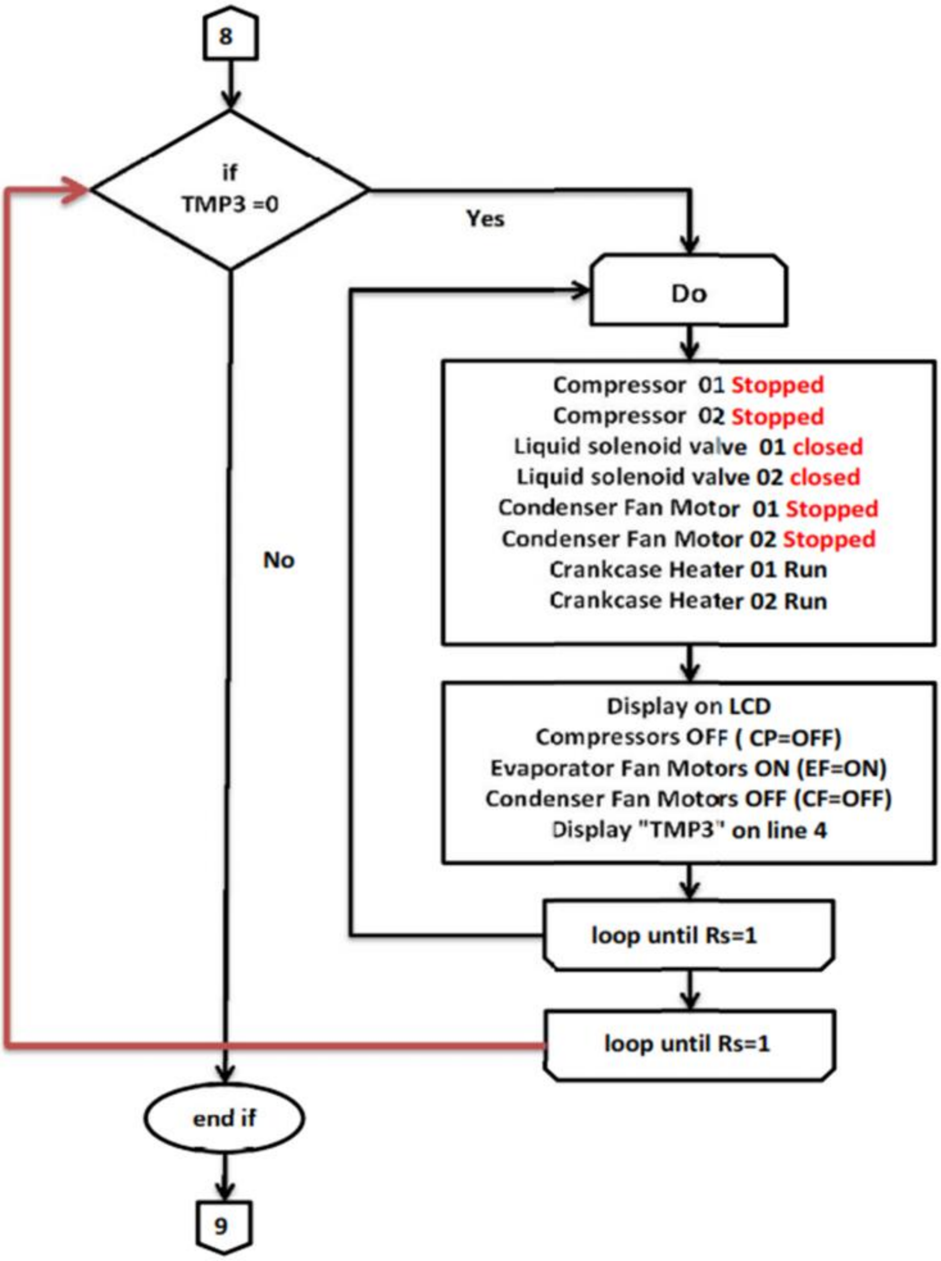


Figure (4.11) The Sequence of Thermal Motor Protection 03 Alarm.

When the TMP3 alarm is turned on, the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan ON until pressed Reset switch (as “RS”), then the microcontroller will check a gain the TMP3 alarm is found or not, if pressed Reset switch again & TMP3 alarm is not found, then the controller will go to main program.

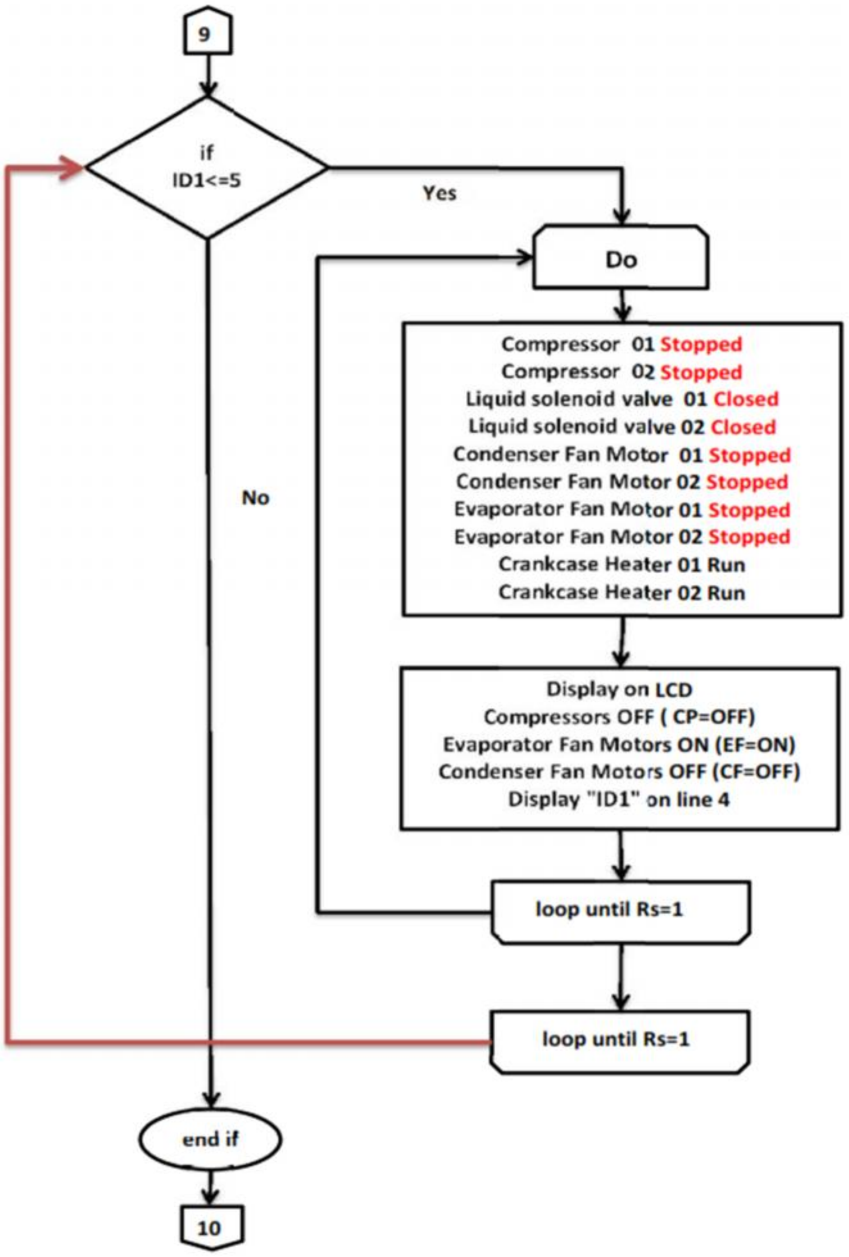


Figure (4.12) The Sequence of Indoor Sensor Temperature 01 Alarm.

When the is value measuring by Indoor Temperature sensor 01 less than or equal to 5°C the HVAC will give alarm ID1 and the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors, Evaporator Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan OFF until pressed Reset switch (as “RS”), then the microcontroller will check a gain the ID1 alarm is found or not, if pressed Reset switch again & ID1 alarm is not found, then the controller will go to main program.

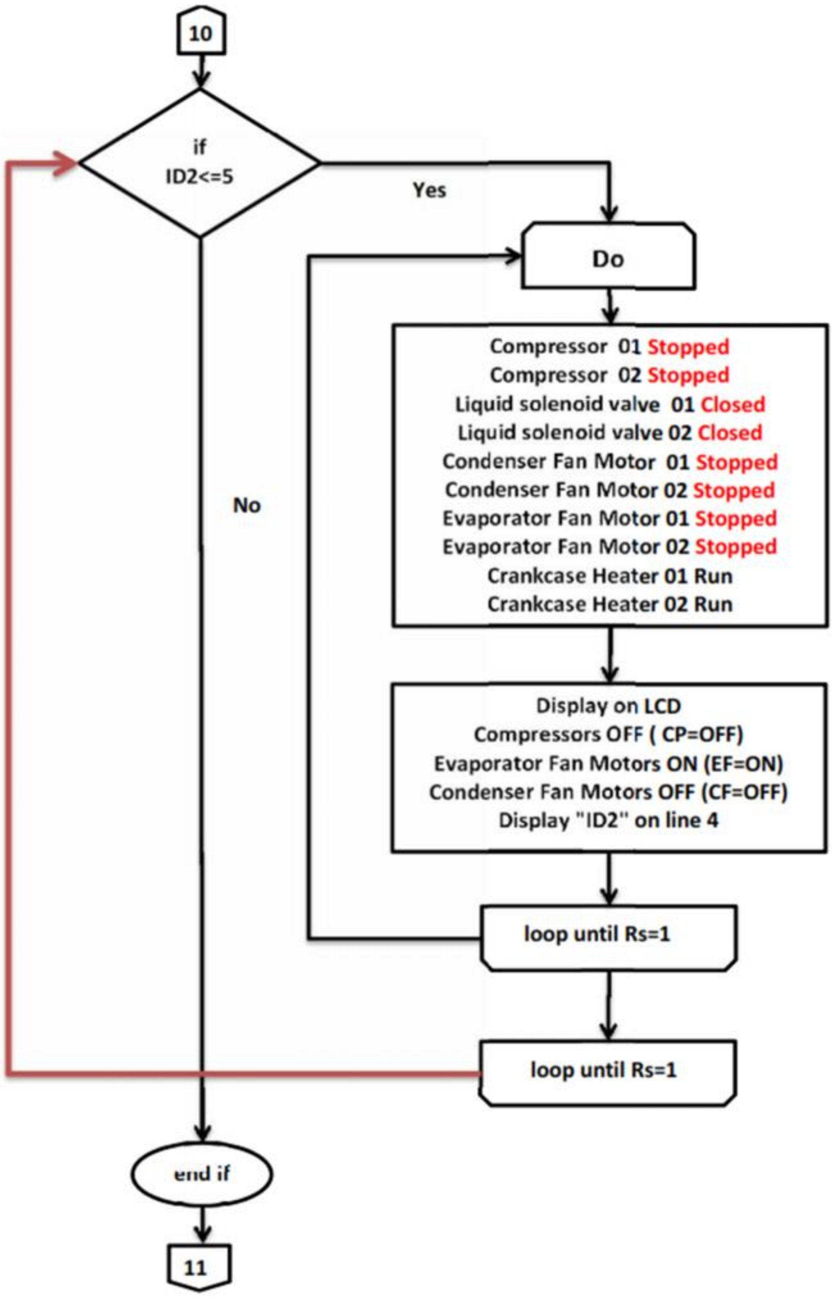


Figure (4.13) The Sequence of Indoor Sensor Temperature 02 Alarm.

When the is value measuring by Indoor Temperature sensor 02 less than or equal to 5°C the HVAC will give alarm ID2 and the Microcontroller will stopped Compressors, Liquid solenoid valves, Condenser Fan Motors, Evaporator Fan Motors & operating the Crankcase Heaters for Compressors & displaying on LCD the status of Compressors OFF, Condenser Fans, Evaporator Fan OFF until pressed Reset switch (as “RS”), then the microcontroller will check a gain the ID2 alarm is found or not, if pressed Reset switch again & ID2 alarm is not found, then the controller will go to main program.

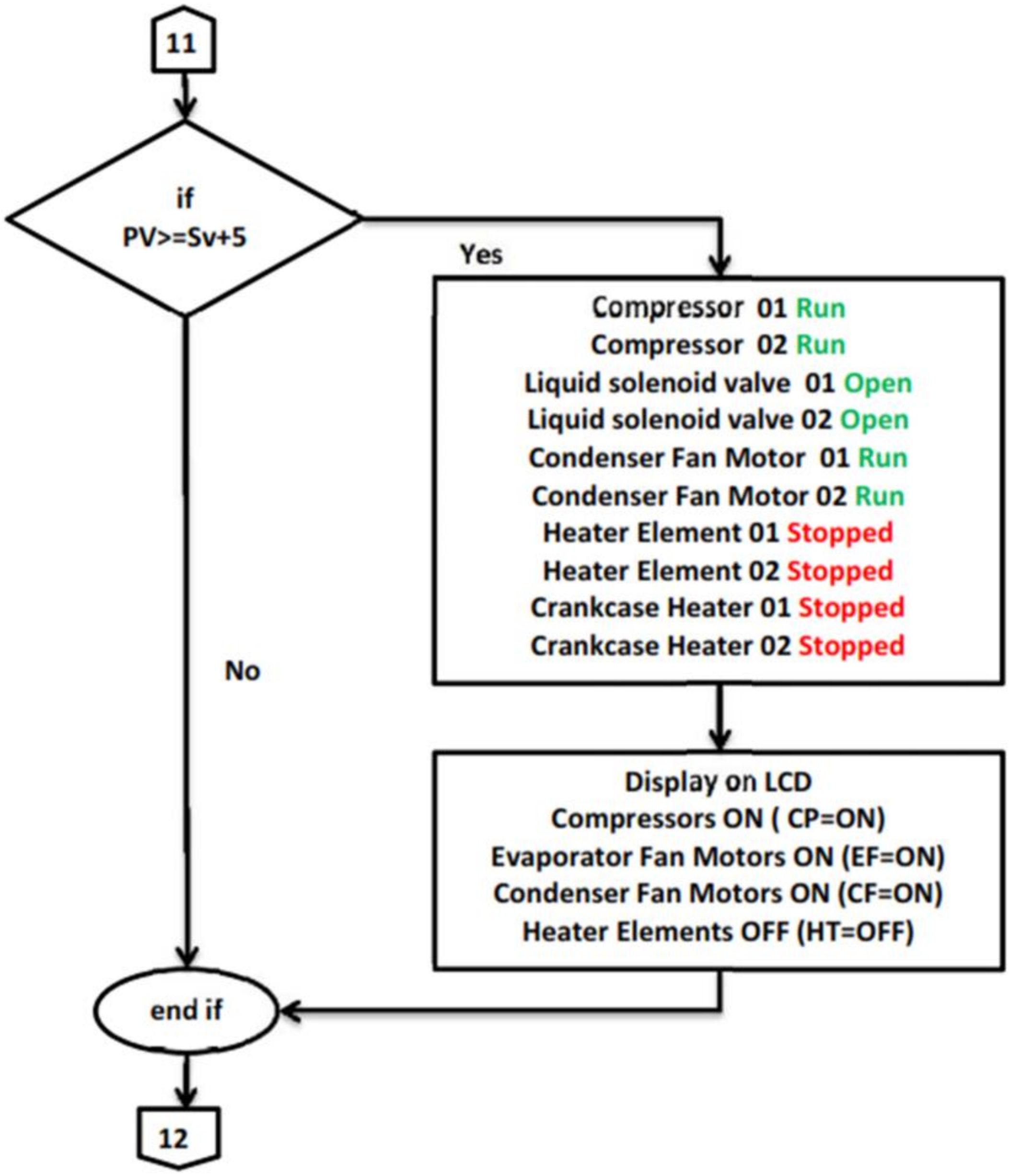


Figure (4.14) The Sequence of HVAC system when the Present value ≥ Set value plus 5 °C.

The microcontroller monitoring the Present value "PV" & when the present value greater than or equal the Set value "SV"+ 5°C the Microcontroller will operate the Compressors, Condenser Fan Motors and Open the Liquid solenoid valves and stopped the Crankcase Heaters for Compressors & Heater Elements. In addition to displaying on LCD the status of Compressors, Condenser Fans, Evaporator Fan ON & Heater Elements OFF and go to main program.

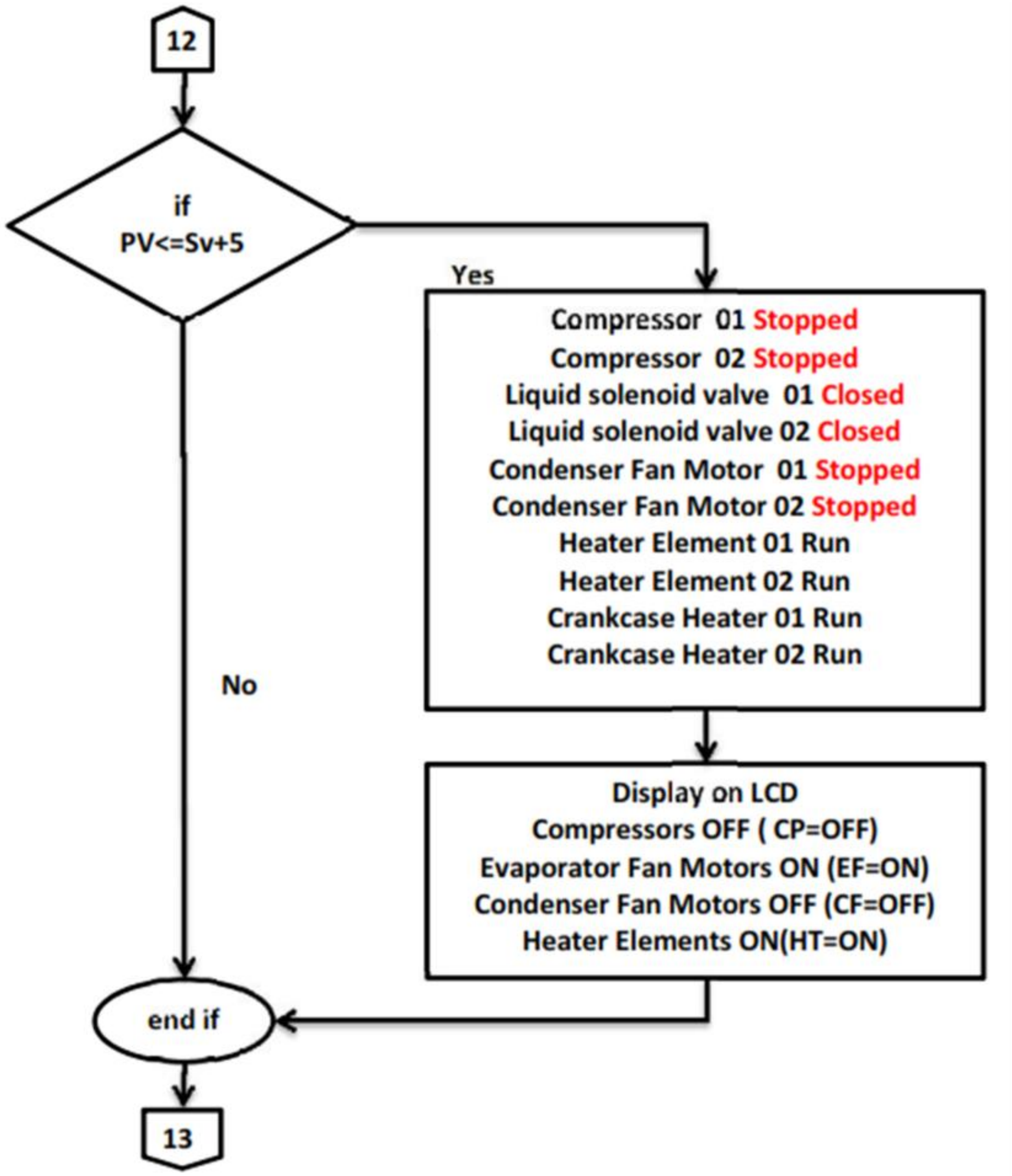


Figure (4.15) The Sequence of HVAC system when the Present value ≤ Set value plus 5 °C.

When the present value “PV” greater than or equal the Set value “SV”+ 5℃ the Microcontroller will stopped the Compressors, Condenser Fan Motors and Closed the Liquid solenoid valves and operate the Crankcase Heaters for Compressors & Heater Elements. In addition to displaying on LCD the status of Compressors, Condenser Fans OFF, Evaporator Fan ON & Heater Elements ON and go to main program.

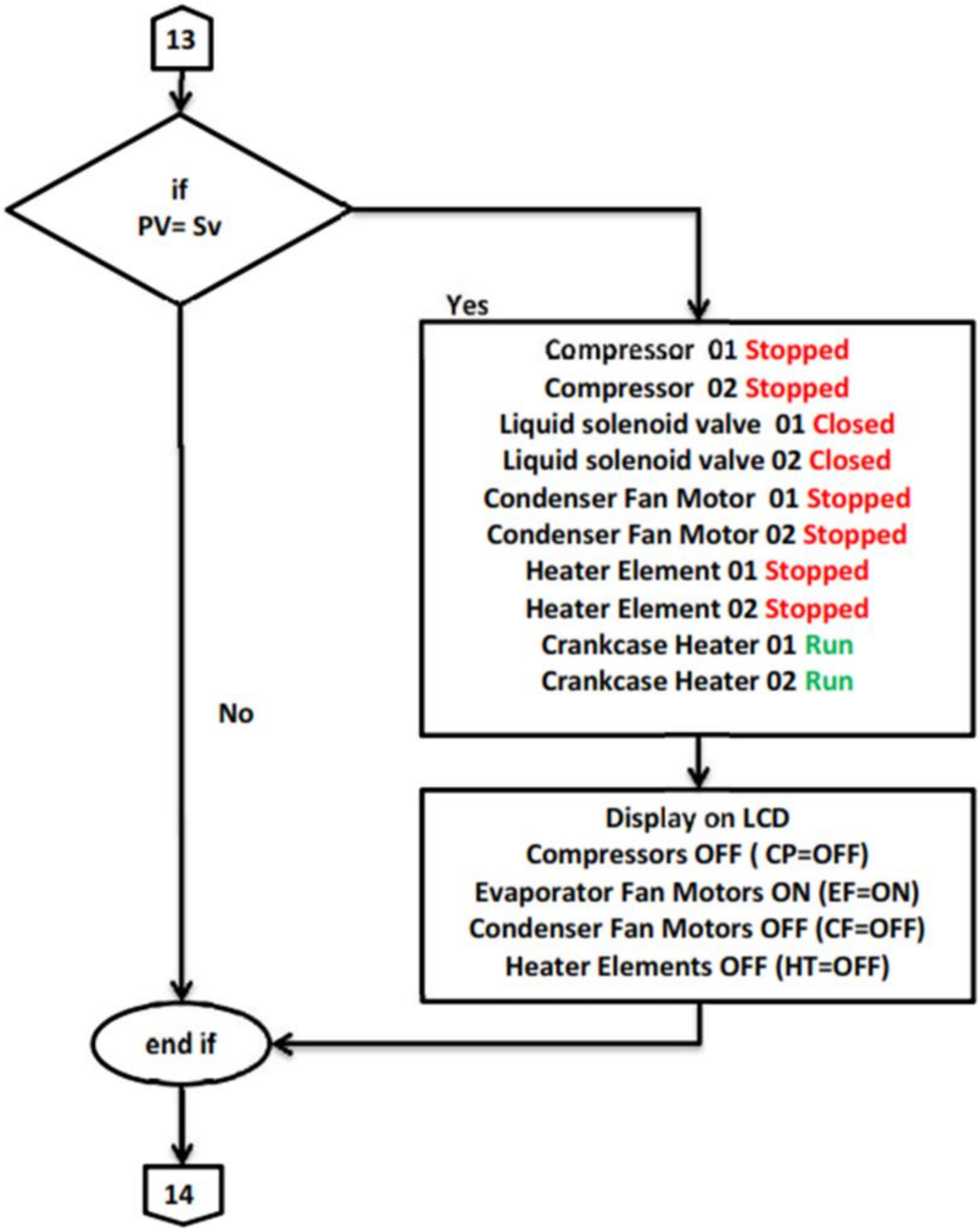


Figure (4.16) The Sequence of HVAC system when the Present value equal to Set value.

When the present value “PV” equal to the Set value “SV” the Microcontroller will stopped the Compressors, Condenser Fan Motors, and Heater Elements and Closed the Liquid solenoid valves and operate the Crankcase Heaters for Compressors. In addition to displaying on LCD the status of Compressors, Condenser Fans , Heater Elements OFF, Evaporator Fan ON and go to main program.

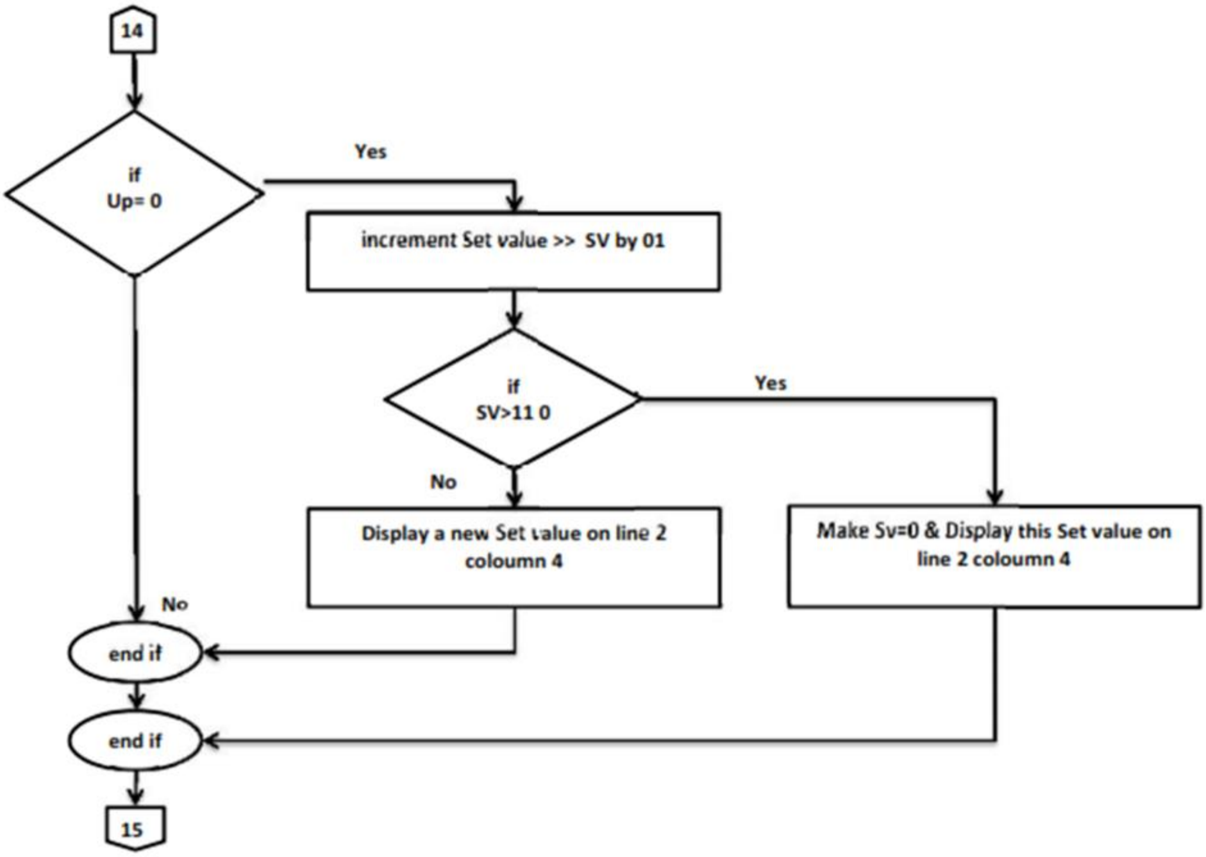


Figure (4.17) The Procedure of HVAC system when the Scroll up Temperature is pressed.

The set value of HVAC system is control by two switches when we need to increase the set value, it pressed the Scroll Up switch “UP” , the set value is incremented by one.

When the set value is greater than 110 , the microcontroller will make the set value “SV” is equal zero & displaying this value on LCD locate(2,4), else the microcontroller will displaying on LCD a new set value on line 2 Column 4 and go to main program.

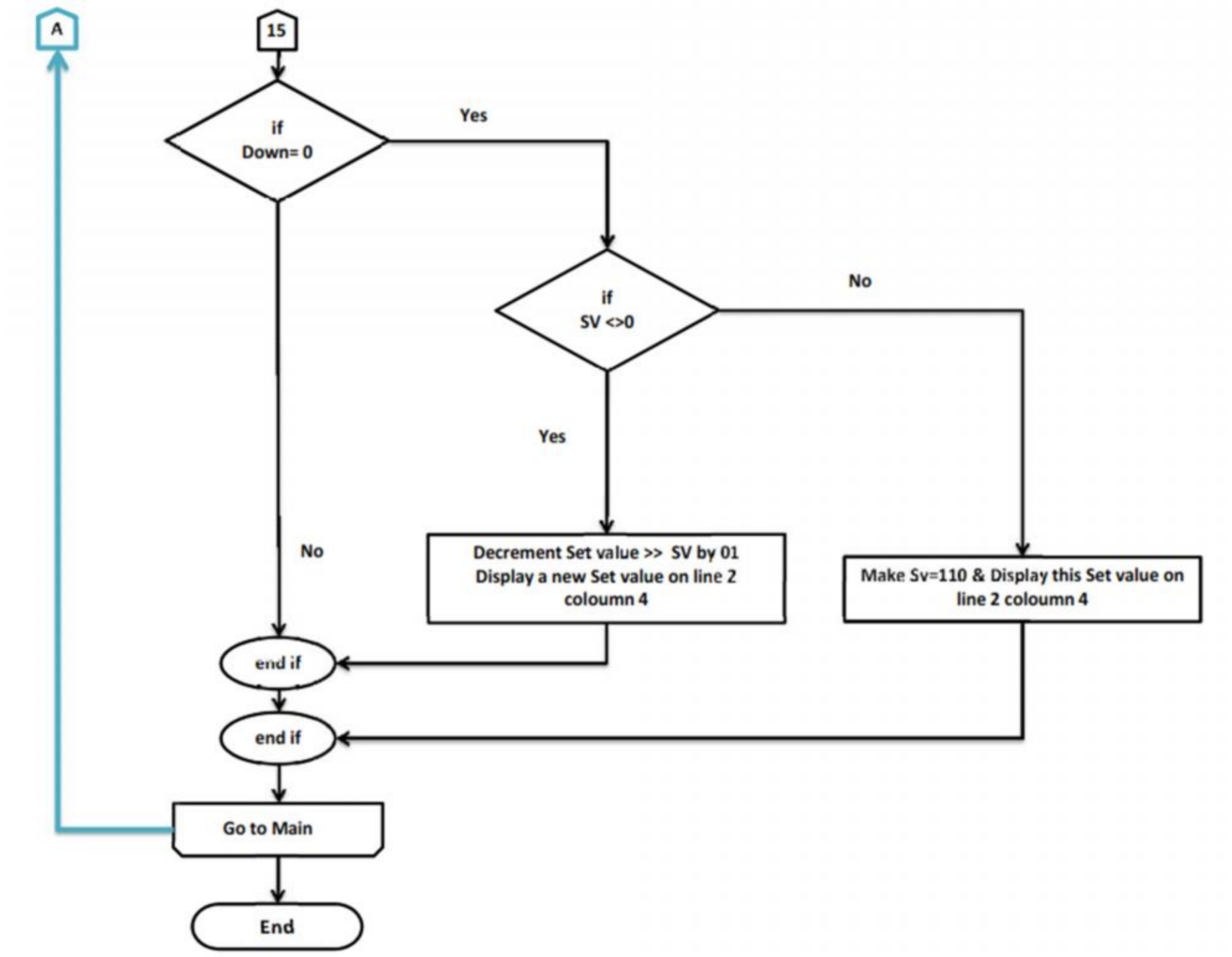


Figure (4.18) The Procedure of HVAC system when the Scroll down Temperature is pressed.

When the Scroll down switch “Down” is pressed & the Set value is not equal to zero, the set value will decrease by one & microcontroller will display this a new value on LCD on line 2 column 4, else the microcontroller will make the set value is equal to 110 & displaying this value on LCD at the same location and go to main program.

Chapter Five

Result & Discussion

5.1 Result:

After our Simulation, we find out that we can save a temperature building according to set point on HVAC Unit with acceptable zone. So our saving results shows,

Here we assumed that,

SN.	Condition	Action
1	PV<= SV-5	1. Compressors OFF. 2. Condenser Fan Motors OFF. 3. Liquid solenoid valves OFF. 4. Crankcase Heaters ON. 5. Heater Elements ON. 6. Evaporator Fan Motor ON.
2	PV< SV+5 & PV> SV-5	1. Compressors OFF. 2. Condenser Fan Motors OFF. 3. Liquid solenoid valves OFF. 4. Crankcase Heaters ON. 5. Heater Elements OFF. 6. Evaporator Fan Motor ON.
3	PV>= SV+5	1. Compressors ON. 2. Condenser Fan Motors ON. 3. Liquid solenoid valves ON. 4. Crankcase Heaters OFF. 5. Heater Elements OFF. 6. Evaporator Fan Motor ON.

5.2 Discussion:

From a previous chapter, we get the following points:

When the HVAC system gives alarm High pressure switch 01 “HP1”, which is erected on Liquid line for Compressor01or give alarm High pressure switch 02 “HP2”, which is erected on Liquid line Compressor02, and the probabilities & possible causes is :

- Air in system
- Clogged Condenser
- Liquid solenoid valve01 or 02 closed.
- Overcharged system.
- Insufficient condenser air.
- Loose fan belt.

When the HVAC system gives alarm Low pressure switch 01 “LP1”, which is erected on suction line for Compressor01or give alarm High pressure switch 02 “LP2”, which is erected on suction line for Compressor02, and the probabilities & possible causes is :

- Refrigerant shortage.
- Compressor gasket leakage.
- Compressor suction valve leakage.
- Moisture in system.

When the HVAC system gives alarm Motor Protection switch 01 “MP1”, which is erected on one phase for Compressor01or give alarm Motor Protection switch 02 “MP2”, which is erected on one phase for Compressor02, and the probabilities & possible causes is:

- Compressor01 or 02 overloads.

When the HVAC system gives alarm Thermal Motor Protection switch 01, 02 or 03 “TMP1, TMP2 or TMP3”, which is erected on winding of Condenser Fan Motor & evaporator Fan Motors, and the probabilities & possible causes, is:

- Defective fan Motor Capacitor.
- Loose leads at fan motor.
- Fan motor burned out.
- Motor bearing Problem.

When the HVAC system gives alarm Indoor temperature sensor 01 or 02 “ID1 or ID2”, which is erected on Evaporator Coil of HVAC system, the probabilities & possible causes is:

- Clogged Evaporator coil by accumulated dust.
- Low refrigerant charge.
- Indoor unit frosted.
- Restriction in suction tube.
- Capillary or accurate restricted or ice clogged.

Chapter Six

Conclusion & Recommendations

6.1 Conclusion:

In this thesis the controller is monitoring the temperature and protecting the HVAC system by a several a switches group & two temperature sensors.

The control of HVAC system is done with the help of one temperature sensors. The temperature value is displayed on the LCD screen and also we can set the desired values of temperature with the help of scroll up & down switches. The entire decision making is done with a help of a microcontroller. This type of Controller system can be installed in any HVAC unit where we need to maintain temperature intensities approximately constant. Another objective of the project work is to conserve energy by using only the necessary amount of energy.

The system has various advantages over other similar systems as it is relatively cheap, smaller size, on-device display, less complexity and greater portability.

6.2 Recommendations:

We employ some more sensors like barometer and humidity sensor then the measurements of temperature, atmospheric pressure and relative humidity remotely is not only important in environmental or weather monitoring but also crucial for many industrial processes.

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Appendix

Bascom Program Code

```
'TITLE BLOCK    :CONTROLLER OF HVAC SYSTEM

'AUTHOR         :MOHAMMED AHMED ELTAYEB ELMALIK

'BATCH07        :ATBARA

'QUALIFICATIOIN :M.SC IN MECHATRONIC PROGRAM

'CONTROLLER     :ATMEGA325

'DATE           :12.03.2016

'**************************************************************************************

'                              PROGRAM DESCRIPTION:

'**************************************************************************************

'MAIN OBJECTIVE OF THIS PROJECT IS TO MEASURE AND DISPLAY TEMPERATUR AND CONTROL HEATER
& FANS TO MAINTAIN SET TEMPERATURE

'FOR TEMPERATURE, LM35 TEMPERATURE SENSOR IS USED FOR THIS TOPIC

'**************************************************************************************

' Compiler Directives (these tell Bascom things about our hardware)

$regfile = "m325def.dat"                    'TYPE OF MICRO

$crystal = 1000000                          'SPPED OF MICRO 1 MHz crystal

$swstack = 40

$hwstack = 32

$framesize = 32
```

```
'****************************************************************************************************

'                              CONFIGURE 20X4 LCD

'****************************************************************************************************

Config Lcd = 20 * 4

Config Lcdpin = Pin , Db4 = Portd.4 , Db5 = Portd.5 , Db6 = Portd.6 , Db7 = Portd.7 , E = Portd.0 , Rs =
Portd.1

Cursor Off                                    'MAKE CURSOR OFF

'****************************************************************************************************

'                              CONFIGURE ADC FOR MEASUREMENT OF LM35

'****************************************************************************************************

Config Adc = Single , Prescaler = Auto , Reference = Avcc

Start Adc

'****************************************************************************************************

'                              HARDWARE SETUPS

'****************************************************************************************************

' SETUP DIRTECTION OF ALL PORTS


Config Porta = Input                          'CONFIGURE PORT A AS INPUT

Config Portb = Input                          'CONFIGURE PORT B AS INPUT

Config Portc = Output                         'CONFIGURE PORT C AS OUTPUT

Config Porte = Output                         'CONFIGURE PORT E AS OUTPUT
```

```
'*********************************************************************************

'                              DECLARATION OF I/0

'*********************************************************************************

Up Alias Pina.0                               'SCROLL UP TEMPERATURE SWITCH

Down Alias Pina.1                               'SCROLL DOWN TEMPERATURE SWITCH

Rs Alias Pina.2                               'RESET SWITCH

Hp1 Alias Pinb.0                               'HIGH PRESSURE SWITCH01

Hp2 Alias Pinb.1                               'HIGH PRESSURE SWITCH02

Lp1 Alias Pinb.2                               'LOW PRESSURE SWITCH01

Lp2 Alias Pinb.3                               'LOW PRESSURE SWITCH01

Mp1 Alias Pinb.4                               'MOTOR PROTECTION01

Mp2 Alias Pinb.5                               ''MOTOR PROTECTION02

Tmp1 Alias Pinb.6                               'THERMAL MOTOR PROTECTION01

Tmp2 Alias Pinc.0                               'THERMAL MOTOR PROTECTION01

Tmp3 Alias Pinc.1                               'THERMAL MOTOR PROTECTION03

Cfm1 Alias Pinc.2                               'CONDENSER FAN MOTOR01

Cfm2 Alias Pinc.3                               'CONDENSER FAN MOTOR02

Efm1 Alias Pinc.4                               'EVAPORATOR FAN MOTOR01

Efm2 Alias Pinc.5                               'EVAPORATOR FAN MOTOR02

Heater1 Alias Pinc.6                               'HEATER ELEMENT01

Heater2 Alias Pinc.7                               'HEATER ELEMENT01

Comp1 Alias Pine.0                               'COMPRESSOR01

Comp2 Alias Pine.1                               'COMPRESSOR02

Lsv1 Alias Pine.2                               'LIQUID SOLENOID VALVE01

Lsv2 Alias Pine.3                               'LIQUID SOLENOID VALVE02
```

```
Cch1 Alias Pine.4                          'CRANKCASE HEATER01

Cch2 Alias Pine.5                          'CRANKCASE HEATER02

Comp1 = 0                                  'MAKE COMPRESSOR01 OFF

Comp2 = 0                                  'MAKE COMPRESSOR02 OFF

Cfm1 = 0                                   'MAKE CONDENSER FAN MOTOR01 OFF

Cfm2 = 0                                   'MAKE CONDENSER FAN MOTOR02 OFF
'MAKE CONDENSER FAN MOTOR01 OFF

Efm1 = 1                                   'MAKE EVAPORATOR FAN01 MOTOR ON

Efm2 = 1                                   'MAKE EVAPORATOR FAN02 MOTOR ON

Heater1 = 0                                'MAKE HEATER01 OFF

Heater2 = 0                                'MAKE HEATER2 OFF


'*********************************************************************************

'                          DECLARATION OF VARIABLES

'*********************************************************************************

Dim W As Word , W_single As Single , W_avg As Single

Dim Pv As Integer

Dim Idu1 As Word , Idu2 As Word , Id1 As Integer , Id2 As Integer

Dim Gp As Byte

Dim Sv As Integer , Sv_s As Eram Integer

Dim Hv_h As Integer , Hv_l As Integer

'*********************************************************************************

Deflcdchar 0 , 4 , 14 , 31 , 14 , 4 , 32 , 32 , 32       ' replace [x] with number (0-7)

Cls                                        'CLEAR DISPLAY

Lcd "PV=" ; Spc(3) ; Chr(0) ; "C" ; Spc(2) ; "HT="       'DISPLAY THE PRESENT VALUE & HEATER STATUS ON
LINE 01
```

```
Lowerline

Lcd "SV=" ; Spc(3) ; Chr(0) ; "C" ; Spc(2) ; "CP="        'DISPLAY THE SET VALUE & COMPRESSORS STATUS
ON LINE 02

Locate 3 , 1

Lcd "CF=" ; Spc(4) ; Spc(3) ; "EF="                  'DISPLAY THE STATUS OF CONDENSER FANS &
EVAPORATOR FANS ON LINE 03

Sv = Sv_s

Main:

Debounce Hp1 , 0 , High_pressure1 , Sub

Debounce Hp2 , 0 , High_pressure2 , Sub

Debounce Lp1 , 0 , Low_pressure1 , Sub

Debounce Lp2 , 0 , Low_pressure2 , Sub

Debounce Mp1 , 0 , Comp.motor_protection1 , Sub

Debounce Mp2 , 0 , Comp.motor_protection2 , Sub

Debounce Tmp1 , 0 , Ther_m_pro1 , Sub

Debounce Tmp2 , 0 , Ther_m_pro2 , Sub

Debounce Tmp3 , 0 , Ther_m_pro3 , Sub

Locate 4 , 1

Lcd "Run"

    Gosub Measure_lm35

    Gosub Check_temp

    Gosub Indoor_sensor1

    Gosub Indoor_sensor2

    Debounce Up , 0 , Sv_up

    Debounce Down , 0 , Sv_down

    Goto Main
```

```
'*********************************************************************************

'HEAR WE MEASURE TEMPERATURE FROM LM35 SENSOR

'FIRST WE MEASURE THE ADC COUNT AT 'W'

'AS WE KNOW ADC WILL COUNT MAXIMUM VALUE(1024) AT 5V

'WE CAN PER COUNT VALUE BY THE FORMULA,

'W_SINGLE=(WX5)/1024=WX0.005

'I.E. EACH COUNT IS EQUAL TO 5mV

'NOW FROM DATA SHEET OF LM35 WE KNOW THAT LM35 WILL

'OUTPUT 10mV PER DEGREE CENTRIGATE

'SO EACH COUNT=W_SINGLE/2 DEGREE CENTRIGATE

'FOR ACCURACY WE TAKE 100 SAMPLE AND THEN TAKE AVARAGE

'*********************************************************************************

Measure_lm35:

      W_avg = 0

      For Gp = 1 To 100

        W = Getadc(0)

        'W_single = W * 5                      'CHECK MATH FOR LM35

        'W_single = W_single / 1024

        'W_single = W_single / 2

        If W <> 0 Then

          W_single = W / 2

          Else

          W_single = 0

          End If

        W_avg = W_avg + W_single
```

```
  Next Gp
 If W_avg <> 0 Then
  W_avg = W_avg / 100                    'MAKE AVAGARE OF DISPLAY
  Else
  W_avg = 0
  End If
 Pv = W_avg                              'TO IGNORE THE FRACTION
 Locate 1 , 4                            'LOCATE THE DISPALY VALUE LOCATION
 Lcd Spc(3)                              'ERASE OLD VALUE
 Locate 1 , 4                            'LOCATE THE DISPLAY VALUE LOCATION
 Lcd Pv                                  'DISPLAY THE CURRENT VALUE
 Locate 2 , 4
 Lcd Spc(3)
 Locate 2 , 4
 Lcd Sv                                  'DISPLAY THE SET VALUE
 Return
'*************************************************************************************
'                        //    HERE WE INCREASE SET TEMPERATURE VALUE BY 1
'*************************************************************************************
Sv_up:
 Incr Sv                                 'INCREMENT SV BY 1
 If Sv > 110 Then
  Sv = 0
  End If
 Sv_s = Sv                               'SAVE SV AT EEPROM
```

```
        Locate 2 , 4

        Lcd Spc(3)

        Locate 2 , 4

        Lcd Sv

        Goto Main

'******************************************************************************************

'                                    HERE WE DECREASE SET TEMPERATURE VALUE BY 1

'******************************************************************************************

Sv_down:

        If Sv <> 0 Then

          Decr Sv                                 'DECREASE SV BY 1

          Else

          Sv = 110

          End If

        Sv_s = Sv                                 'SAVE SV AT EEPROM

        Locate 2 , 4

        Lcd Spc(3)

        Locate 2 , 4

        Lcd Sv

        Goto Main

'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@

Check_temp:

        Hv_h = Sv + 1                             'HYSTERISYS=1

        If Pv >= Hv_h Then

          Comp1 = 1                               'TURN ON THE COMPRESSOR01
```

```
  Comp2 = 1                          'TURN ON THE COMPRESSOR02
  Lsv1 = 1                         'TURN ON THE LIQUID SOLENOID VALVE01
  Lsv2 = 1                         'TURN ON THE LIQUID SOLENOID VALVE02
  Heater1 = 0                        'TURN OFF HEATER01
  Heater2 = 0                        'TURN OFF HEATER02
  Cfm1 = 1                          'TURN OFF CONDENSER FAN01
  Cfm2 = 1                          'TURN OFF CONDENSER FAN02
  Cch1 = 0                         'TURN OFF CRANKCASE HEATER01
  Cch2 = 0                         'TURN OFF CRANKCASE HEATER02
  Locate 1 , 14
  Lcd Spc(3)
  Locate 1 , 14
  Lcd "OFF"
  Locate 2 , 14
  Lcd Spc(3)
  Locate 2 , 14
  Lcd "ON"
  Locate 3 , 14                      'TURN ON EVAPORATOR FAN MOTOR
  Lcd "ON"
  Locate 3 , 4
  Lcd "ON "
  End If
Hv_l = Sv - 1                        'HYSTERISYS=1
If Pv <= Hv_l Then
  Comp1 = 0                          'TURN OFF COMPRESSOR01
```

```
  Comp2 = 0                     'TURN OFF COMPRESSOR02
  Lsv1 = 0                      'TURN OFF THE LIQUID SOLENOID VALVE01
  Lsv2 = 0                      'TURN OFF THE LIQUID SOLENOID VALVE02
  Heater1 = 1                   'TURN ON HEATER01
  Heater2 = 1                   'TURN ON HEATER02
  Cfm1 = 0                      'TURN ON CONDENSER FAN01
  Cfm2 = 0                      'TURN ON CONDENSER FAN02
  Cch1 = 1                      'TURN ON CRANKCASE HEATER01
  Cch2 = 1                      'TURN ON CRANKCASE HEATER02
  Locate 1 , 14
  Lcd Spc(3)
  Locate 1 , 14
  Lcd "ON"
  Locate 2 , 14
  Lcd Spc(3)
  Locate 2 , 14
  Lcd "OFF"
  Locate 3 , 14                 'TURN ON EVAPORATOR FAN MOTOR
  Lcd "ON"
  Locate 3 , 4
  Lcd "OFF"
  End If
If Pv > Hv_l And Pv < Hv_h Then
  Comp1 = 0                     'TURN OFF COMPRESSOR01
  Comp2 = 0                     'TURN OFF COMPRESSOR02
```

```
Lsv1 = 0                          'TURN OFF THE LIQUID SOLENOID VALVE01
Lsv2 = 0                          'TURN OFF THE LIQUID SOLENOID VALVE02
Heater1 = 0                       'TURN OFF HEATER01
Heater2 = 0                       'TURN OFF HEATER02
Cfm1 = 0                          'TURN OFF CONDENSER FAN01
Cfm2 = 0                          'TURN OFF CONDENSER FAN02
Cch1 = 1                          'TURN ON CRANKCASE HEATER01
Cch2 = 1                          'TURN ON CRANKCASE HEATER02
Locate 1 , 14
Lcd Spc(3)
Locate 1 , 14
Lcd "OFF"
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "OFF"
Locate 3 , 4
Lcd "OFF"
End If
Return
```

```
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                              HIGH PRESSURE SWITCH01 -ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
High_pressure1:
        Do
        If Hp1 = 0 Then
        Comp1 = 0                          'TURN OFF COMPRESSOR01
        Comp2 = 0                          'TURN OFF COMPRESSOR02
        Lsv1 = 0                         'TURN OFF THE LIQUID SOLENOID VALVE01
        Lsv2 = 0                         'TURN OFF THE LIQUID SOLENOID VALVE02
        Cfm1 = 0                          'TURN ON CONDENSER FAN01
        Cfm2 = 0                          'TURN ON CONDENSER FAN02
        Cch1 = 1                          'TURN ON CRANKCASE HEATER01
        Cch2 = 1                          'TURN ON CRANKCASE HEATER02
        Locate 4 , 1
        Lcd "        "
        Do
        Locate 3 , 14
        Lcd "ON"
        Locate 2 , 14
        Lcd Spc(3)
        Locate 2 , 14
        Lcd "OFF"
        Locate 3 , 4
        Lcd "OFF"
```

```
Locate 4 , 1
Lcd "HP1"
Waitms 200
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "   "
Locate 3 , 4
Lcd Spc(3)
Lcd "   "
Locate 4 , 1
Lcd "   "
Waitms 200
Loop Until Rs = 1
End If
Waitms 30
Loop Until Rs = 1
Waitms 30
Do
Loop Until Rs = 0
Waitms 30
 Locate 4 , 1
Lcd "   "
Return
```

```
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                    HIGH PRESSURE SWITCH02-ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
High_pressure2:
    Do
    If Hp2 = 0 Then
    Comp1 = 0                   'TURN OFF COMPRESSOR01
    Comp2 = 0                   'TURN OFF COMPRESSOR02
    Lsv1 = 0                    'TURN OFF THE LIQUID SOLENOID VALVE01
    Lsv2 = 0                    'TURN OFF THE LIQUID SOLENOID VALVE02
    Cfm1 = 0                    'TURN ON CONDENSER FAN01
    Cfm2 = 0                    'TURN ON CONDENSER FAN02
    Cch1 = 1                    'TURN ON CRANKCASE HEATER01
    Cch2 = 1                    'TURN ON CRANKCASE HEATER02
    Locate 4 , 1
    Lcd "        "
    Do
    Locate 3 , 14
    Lcd "ON"
    Locate 2 , 14
    Lcd Spc(3)
    Locate 2 , 14
    Lcd "OFF"
    Locate 3 , 4
    Lcd "OFF"
```

```
Locate 4 , 1
Lcd "HP2"
Waitms 200
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "   "
Locate 3 , 4
Lcd Spc(3)
Lcd "   "
Locate 4 , 1
Lcd "   "
Waitms 200
Loop Until Rs = 1
End If
Waitms 30
Loop Until Rs = 1
Waitms 30
Do
Loop Until Rs = 0
Waitms 30
 Locate 4 , 1
Lcd "   "
Return
```

```
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                              LOW PRESSURE SWITCH01-ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
Low_pressure1:
        Do
        If Lp1 = 0 Then
        Comp1 = 0                    'TURN OFF COMPRESSOR01
        Comp2 = 0                    'TURN OFF COMPRESSOR02
        Lsv1 = 0                   'TURN OFF THE LIQUID SOLENOID VALVE01
        Lsv2 = 0                   'TURN OFF THE LIQUID SOLENOID VALVE02
        Cfm1 = 0                    'TURN ON CONDENSER FAN01
        Cfm2 = 0                    'TURN ON CONDENSER FAN02
        Cch1 = 1                   'TURN ON CRANKCASE HEATER01
        Cch2 = 1                   'TURN ON CRANKCASE HEATER02
        Locate 4 , 1
        Lcd "      "
        Do
        Locate 3 , 14
        Lcd "ON"
        Locate 2 , 14
        Lcd Spc(3)
        Locate 2 , 14
        Lcd "OFF"
        Locate 3 , 4
        Lcd "OFF"
```

```
Locate 4 , 1
Lcd "LP1"
Waitms 200
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "   "
Locate 3 , 4
Lcd Spc(3)
Lcd "   "
Locate 4 , 1
Lcd "   "
Waitms 200
Loop Until Rs = 1
End If
Waitms 30
Loop Until Rs = 1
Waitms 30
Do
Loop Until Rs = 0
Waitms 30
 Locate 4 , 1
Lcd "   "
Return
```

```
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                       LOW PRESSURE SWITCH02-ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
Low_pressure2:
      Do
      If Lp2 = 0 Then
      Comp1 = 0                    'TURN OFF COMPRESSOR01
      Comp2 = 0                    'TURN OFF COMPRESSOR02
      Lsv1 = 0                     'TURN OFF THE LIQUID SOLENOID VALVE01
      Lsv2 = 0                     'TURN OFF THE LIQUID SOLENOID VALVE02
      Cfm1 = 0                     'TURN ON CONDENSER FAN01
      Cfm2 = 0                     'TURN ON CONDENSER FAN02
      Cch1 = 1                     'TURN ON CRANKCASE HEATER01
      Cch2 = 1                     'TURN ON CRANKCASE HEATER02
      Locate 4 , 1
      Lcd "      "
      Do
      Locate 3 , 14
      Lcd "ON"
      Locate 2 , 14
      Lcd Spc(3)
      Locate 2 , 14
      Lcd "OFF"
      Locate 3 , 4
      Lcd "OFF"
```

```
Locate 4 , 1
Lcd "LP2"
Waitms 200
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "   "
Locate 3 , 4
Lcd Spc(3)
Lcd "   "
Locate 4 , 1
Lcd "   "
Waitms 200
Loop Until Rs = 1
End If
Waitms 30
Loop Until Rs = 1
Waitms 30
Do
Loop Until Rs = 0
Waitms 30
 Locate 4 , 1
Lcd "   "
Return
```

```
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                     COMPRESSOR MOTOR PROTECTION01-ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
Comp.motor_protection1:
      Do
      If Mp1 = 0 Then
      Comp1 = 0                     'TURN OFF COMPRESSOR01
      Comp2 = 0                     'TURN OFF COMPRESSOR02
      Lsv1 = 0                      'TURN OFF THE LIQUID SOLENOID VALVE01
      Lsv2 = 0                      'TURN OFF THE LIQUID SOLENOID VALVE02
      Cfm1 = 0                      'TURN ON CONDENSER FAN01
      Cfm2 = 0                      'TURN ON CONDENSER FAN02
      Cch1 = 1                      'TURN ON CRANKCASE HEATER01
      Cch2 = 1                      'TURN ON CRANKCASE HEATER02
      Locate 4 , 1
      Lcd "      "
      Do
      Locate 3 , 14
      Lcd "ON"
      Locate 2 , 14
      Lcd Spc(3)
      Locate 2 , 14
      Lcd "OFF"
      Locate 3 , 4
      Lcd "OFF"
```

```
Locate 4 , 1
Lcd "MP1"
Waitms 200
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "   "
Locate 3 , 4
Lcd Spc(3)
Lcd "   "
Locate 4 , 1
Lcd "   "
Waitms 200
Loop Until Rs = 1
End If
Waitms 30
Loop Until Rs = 1
Waitms 30
Do
Loop Until Rs = 0
Waitms 30
 Locate 4 , 1
Lcd "   "
Return
```

```
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                       COMPRESSOR MOTOR PROTECTION02-ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
Comp.motor_protection2:
      Do
      If Mp2 = 0 Then
      Comp1 = 0                    'TURN OFF COMPRESSOR01
      Comp2 = 0                    'TURN OFF COMPRESSOR02
      Lsv1 = 0                     'TURN OFF THE LIQUID SOLENOID VALVE01
      Lsv2 = 0                     'TURN OFF THE LIQUID SOLENOID VALVE02
      Cfm1 = 0                     'TURN ON CONDENSER FAN01
      Cfm2 = 0                     'TURN ON CONDENSER FAN02
      Cch1 = 1                     'TURN ON CRANKCASE HEATER01
      Cch2 = 1                     'TURN ON CRANKCASE HEATER02
      Locate 4 , 1
      Lcd "      "
      Do
      Locate 3 , 14
      Lcd "ON"
      Locate 2 , 14
      Lcd Spc(3)
      Locate 2 , 14
      Lcd "OFF"
      Locate 3 , 4
      Lcd "OFF"
```

```
Locate 4 , 1
Lcd "MP2"
Waitms 200
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "   "
Locate 3 , 4
Lcd Spc(3)
Lcd "   "
Locate 4 , 1
Lcd "   "
Waitms 200
Loop Until Rs = 1
End If
Waitms 30
Loop Until Rs = 1
Waitms 30
Do
Loop Until Rs = 0
Waitms 30
 Locate 4 , 1
Lcd "   "
Return
```

```
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                      THERMAL MOTOR PROTECTION01-ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
Ther_m_pro1:
      Do
      If Tmp1 = 0 Then
      Comp1 = 0                         'TURN OFF COMPRESSOR01
      Comp2 = 0                         'TURN OFF COMPRESSOR02
      Lsv1 = 0                        'TURN OFF THE LIQUID SOLENOID VALVE01
      Lsv2 = 0                        'TURN OFF THE LIQUID SOLENOID VALVE02
      Cfm1 = 0                         'TURN ON CONDENSER FAN01
      Cfm2 = 0                         'TURN ON CONDENSER FAN02
      Cch1 = 1                         'TURN ON CRANKCASE HEATER01
      Cch2 = 1                         'TURN ON CRANKCASE HEATER02
      Locate 4 , 1
      Lcd "        "
      Do
      Locate 3 , 14
      Lcd "ON"
      Locate 2 , 14
      Lcd Spc(3)
      Locate 2 , 14
      Lcd "OFF"
      Locate 3 , 4
      Lcd "OFF"
```

```
Locate 4 , 1
Lcd "TMP1"
Waitms 200
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "   "
Locate 3 , 4
Lcd Spc(3)
Lcd "   "
Locate 4 , 1
Lcd "   "
Waitms 200
Loop Until Rs = 1
End If
Waitms 30
Loop Until Rs = 1
Waitms 30
Do
Loop Until Rs = 0
Waitms 30
 Locate 4 , 1
Lcd "   "
Return
```

```
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                    THERMAL MOTOR PROTECTION02-ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
Ther_m_pro2:
    Do
    If Tmp2 = 0 Then
    Locate 4 , 1
    Comp1 = 0                 'TURN OFF COMPRESSOR01
    Comp2 = 0                 'TURN OFF COMPRESSOR02
    Lsv1 = 0                  'TURN OFF THE LIQUID SOLENOID VALVE01
    Lsv2 = 0                  'TURN OFF THE LIQUID SOLENOID VALVE02
    Cfm1 = 0                  'TURN ON CONDENSER FAN01
    Cfm2 = 0                  'TURN ON CONDENSER FAN02
    Cch1 = 1                  'TURN ON CRANKCASE HEATER01
    Cch2 = 1                  'TURN ON CRANKCASE HEATER02
    Locate 4 , 1
    Lcd "      "
    Do
    Locate 3 , 14
    Lcd "ON"
    Locate 2 , 14
    Lcd Spc(3)
    Locate 2 , 14
    Lcd "OFF"
    Locate 3 , 4
```

```
Lcd "OFF"

Locate 4 , 1

Lcd "TMP2"

Waitms 200

Locate 2 , 14

Lcd Spc(3)

Locate 2 , 14

Lcd "   "

Locate 3 , 4

Lcd Spc(3)

Lcd "   "

Locate 4 , 1

Lcd "   "

Waitms 200

Loop Until Rs = 1

End If

Waitms 30

Loop Until Rs = 1

Waitms 30

Do

Loop Until Rs = 0

Waitms 30

 Locate 4 , 1

Lcd "   "

Return
```

```
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                    THERMAL MOTOR PROTECTION03-ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
Ther_m_pro3:
      Do
      If Tmp3 = 0 Then
      Comp1 = 0                   'TURN OFF COMPRESSOR01
      Comp2 = 0                   'TURN OFF COMPRESSOR02
      Lsv1 = 0                   'TURN OFF THE LIQUID SOLENOID VALVE01
      Lsv2 = 0                   'TURN OFF THE LIQUID SOLENOID VALVE02
      Cfm1 = 0                   'TURN ON CONDENSER FAN01
      Cfm2 = 0                   'TURN ON CONDENSER FAN02
      Efm1 = 0                   'TURN OFF EVAPORATOR FAN01
      Efm2 = 0                   'TURN OFF EVAPORATOR FAN02
      Cch1 = 1                   'TURN ON CRANKCASE HEATER01
      Cch2 = 1                   'TURN ON CRANKCASE HEATER02
      Locate 4 , 1
      Lcd "      "
      Do
      Locate 3 , 14
      Lcd "ON"
      Locate 2 , 14
      Lcd Spc(3)
      Locate 2 , 14
      Lcd "OFF"
```

```
Locate 3 , 4

Lcd "OFF"

Locate 3 , 14

Lcd "OFF"

Locate 4 , 1

Lcd "TMP3"

Waitms 200

Locate 2 , 14

Lcd Spc(3)

Locate 2 , 14

Lcd "   "

Locate 3 , 4

Lcd Spc(3)

Lcd "   "

Locate 3 , 14

Lcd "   "

Locate 4 , 1

Lcd "    "

Waitms 200

Loop Until Rs = 1

End If

Waitms 30

Loop Until Rs = 1

Waitms 30

Do
```

```
        Loop Until Rs = 0
        Waitms 30
         Locate 4 , 1
        Lcd "   "
        Return
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                         INDOOR TEMPERARURE SENSOR PROTECTION01-ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
Indoor_sensor1:
        Do
        Idu1 = Getadc(1)
        If Idu1 <> 0 Then
        Id1 = Idu1 / 2
        Else
        Id1 = 0
        End If
        If Id1 <= 5 Then
        Wait 5
        End If
        If Id1 <= 5 Then
        Comp1 = 0                    'TURN OFF COMPRESSOR01
        Comp2 = 0                    'TURN OFF COMPRESSOR02
        Lsv1 = 0                    'TURN OFF THE LIQUID SOLENOID VALVE01
        Lsv2 = 0                    'TURN OFF THE LIQUID SOLENOID VALVE02
        Cfm1 = 0                     'TURN ON CONDENSER FAN01
```

```
Cfm2 = 0                    'TURN ON CONDENSER FAN02
Efm1 = 0                    'TURN OFF EVAPORATOR FAN01
Efm2 = 0                    'TURN OFF EVAPORATOR FAN02
Cch1 = 1                    'TURN ON CRANKCASE HEATER01
Cch2 = 1                    'TURN ON CRANKCASE HEATER02
Locate 4 , 1
Lcd "          "
Do
Locate 3 , 14
Lcd "ON"
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "OFF"
Locate 3 , 4
Lcd "OFF"
Locate 3 , 14
Lcd "OFF"
Locate 4 , 1
Lcd "ID1"
Waitms 200
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "   "
```

```
Locate 3 , 4
Lcd Spc(3)
Lcd "   "
Locate 3 , 14
Lcd "   "
Locate 4 , 1
Lcd "    "
Waitms 200
Loop Until Rs = 1
Waitms 30
Loop Until Rs = 1
Waitms 30
Do
Loop Until Rs = 0
Waitms 30
 Locate 4 , 1
Lcd "   "
End If
Return
```

```
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
'                    INDOOR TEMPERARURE SENSOR PROTECTION02-ALARM
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
Indoor_sensor2:
    Do
    Idu2 = Getadc(2)
    If Idu2 <> 0 Then
    Id2 = Idu2 / 2
    Else
    Id2 = 0
    End If
    If Id2 <= 5 Then
    Wait 5
    End If
    If Id2 <= 5 Then
    Comp1 = 0                    'TURN OFF COMPRESSOR01
    Comp2 = 0                    'TURN OFF COMPRESSOR02
    Lsv1 = 0                     'TURN OFF THE LIQUID SOLENOID VALVE01
    Lsv2 = 0                     'TURN OFF THE LIQUID SOLENOID VALVE02
    Cfm1 = 0                     'TURN ON CONDENSER FAN01
    Cfm2 = 0                     'TURN ON CONDENSER FAN02
    Efm1 = 0                     'TURN OFF EVAPORATOR FAN01
    Efm2 = 0                     'TURN OFF EVAPORATOR FAN02
    Cch1 = 1                     'TURN ON CRANKCASE HEATER01
    Cch2 = 1                     'TURN ON CRANKCASE HEATER02
```

```
Locate 4 , 1
Lcd "           "
Do
Locate 3 , 14
Lcd "ON"
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "OFF"
Locate 3 , 4
Lcd "OFF"
Locate 3 , 14
Lcd "OFF"
Locate 4 , 1
Lcd "ID2"
Waitms 200
Locate 2 , 14
Lcd Spc(3)
Locate 2 , 14
Lcd "   "
Locate 3 , 4
Lcd Spc(3)
Lcd "   "
Locate 3 , 14
Lcd "   "
```

```
        Locate 4 , 1
        Lcd "    "
        Waitms 200
        Loop Until Rs = 1
        Waitms 30
        Loop Until Rs = 1
        Waitms 30
        Do
        Loop Until Rs = 0
        Waitms 30
         Locate 4 , 1
        Lcd "   "
        End If
        Return
'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
End                                 'end program
```