# AUTOMATION OF CHILLER PLANT USING MICRO CONTROLLER

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***Abstract*— This paper deals with automation of chiller plant using microcontroller. The main objective of this project is to reduce the manpower in BHEL for switching on and off . A microcontroller program is designed to automatically switch on the various units with the required time delay. The operator is also alerted incase of faults with the use of GSM modem. The operator will receive messages in case of fault conditions like power failure of various units and also temperature exceedance.This therefore reduce the time and cost.**

## 1. INTRODUCTION

A chiller is a machine that removes heat by vapour compression or absorption refrigeration cycle. Performance, efficiency, maintenance, and product life cycle environmental Impact are the main concerns in design and selection of chillers. The main specifications are total life cycle cost, chiller IP rating, the power source, evaporator material, evaporator type, evaporator capacity, chiller cooling capacity, type of compressor, number of compressor, condenser material, condenser capacity, motor fan type, noise level, internal piping material, number of fridge circuits, coolant requirement, ambient temperature and COP(the ratio between cooling capacity in RT to the energy consumed by the whole chiller in KW).Chiller efficiency is specified in kilowatts per refrigeration ton(Kw/RT).The two main types of chiller are air cooled chiller and water cooled chiller. In BHEL air cooled chiller is commonly used.The fig 1 shows the air cooled chiller installed in BHEL.

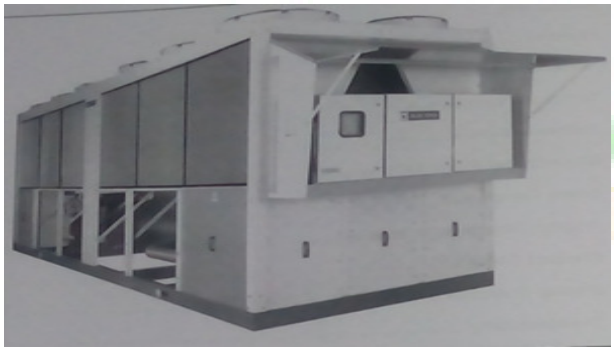


FIG 1:AIR COOLED CHILLER

## 2. REFRIGERATION CYCLE

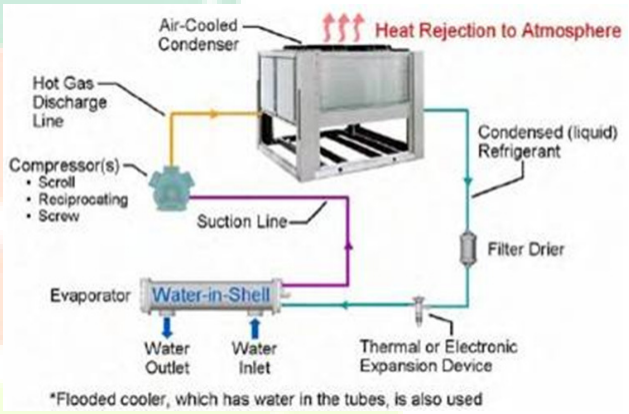



FIG:2 CYCLE OF REFRIGERATION

Air cooled chiller utilize refrigeration cycle to produce chilled water .The building heat is rejected to the ambient temperature with an air cooled condensed coil. In this diagram, first the water enters into the evaporator and is cooled by the refrigerant. Then the super-heated refrigerant vapor enters the suction inlet of the compressor. In the compressor the refrigerant is compressed, raising its pressure and temperature. Now the high pressure and temperature refrigerant gas exits the compressor, passes through the discharge line and enters the condenser. The hot gas is condensed to liquid inside the tubes as it gives up heat to the cooler. The condensed liquid refrigerant then leaves the condenser and enters the expansion device. As the refrigerant passes through the expansion device its temperature and pressure is decreased. They are decreased to the point that some of the liquid flashes to vapour.The expansion device controls the amount of flashing to maintain a certain superheat. It is to ensure that no liquid droplets enter into compressor suction. After leaving the expansion device the refrigerant enters the evaporator. The cycle is then repeated. This cycle of refrigeration is shown in fig 2.

## 3. EXISTING MODEL

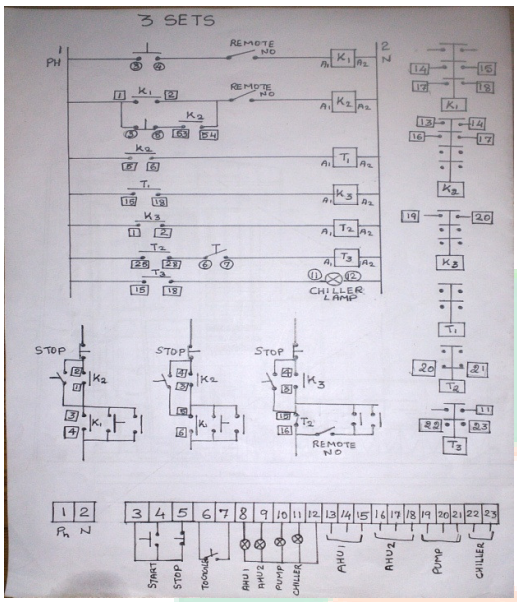



FIG:3 LADDER DIAGRAM OF EXISTING MODEL

Existing model is implemented by analog circuit. The above figure 3 is the ladder diagram of a analog circuit implemented now in BHEL.Initially the chiller plant is switched on by external contact switch .Then AIR HEAD unit 0(K1) is initially switched on and then a timer set for 30 sec delay and then AIR HEAD unit 1(K2) is switched on and again timer T1 is a set again for 30 sec delay and now the PUMP is switched on and then again the timer is set to 1 sec delay for the pump to start up which acts as a temporary bypass timer and then timer is again set to 30 sec delay and then CHILLER is switched on .In existing model if any fault occurs in the system the chiller operator must go to the chiller site and use the remote no to find the fault .The remote no is used to operate the air head 0 and air head 1 seperatly.It is also used in maintenance purpose of the unit.

## 4. PROPOSED MODEL

BLOCK DIAGRAM:

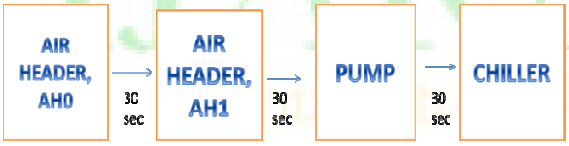



FIG:4 BLOCK DIAGRAM OF SEQUENCE OF SWITCHING

The above fig 4 is the block diagram for switching on the chiller in BHEL. The various units that have to be switched on before switching on the chiller are air header AH0, air header AH1, pump and chiller. The air conditioning units are normally designed to supply a constant air volume or a variable air volume for a low, medium or high velocity air distribution. Normally it is located outside the conditioned area. The pump used in BHEL is a 5 HP pump. In BHEL normally the air header AH0 is switched on and after a delay of 30 seconds the air header AH1 is switched on. After another 30 seconds delay the pump is switched on. Finally after another 30 seconds delay the chiller is switched on. Similar to this procedure three units of chillers are switched on. All these switching processes are done manually in BHEL. To reduce manpower required for switching on these equipment's we have designed a microcontroller program. With the use of the program we can switch on all the units with the required time delay and thus reducing the manpower wasted for switching on the units. We have also designed a GSM modem which will alert the operator in case of fault conditions like power supply failure in any of the units, temperature exceedance of the chiller(which has to be maintained between 20-24 degree), and current exceedance.

## 5. PIC MICROCONTROLLER:

PIC microcontroller is a specialized family of microchip technology.PIC stands for "Peripheral Interface Controller". This micro controller is a compact microcomputer. It is used in embedded system for example robots, motor vehicles, home appliances. The microcontroller consists of processor, memory and peripheral. The features of microcontroller are low cost and reprogrammable with built in EEPROM (electrically erasable programmable read only memory).It has a set of registers that also function as a RAM(random access memory).PIC is divided into 16family.In this family we are using "PIC16F877A".

## 6. PIN DIAGRAM OF PIC16F877A

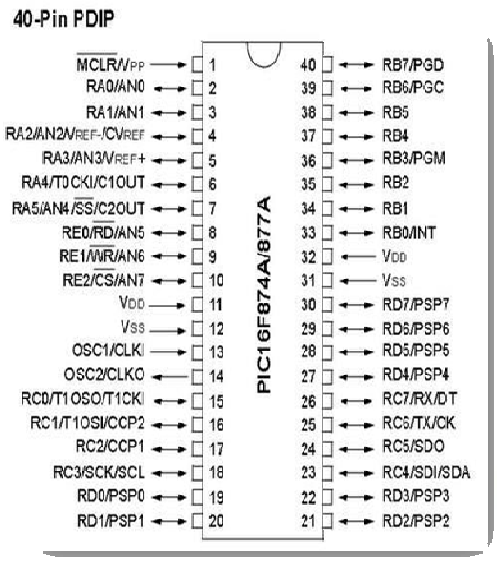
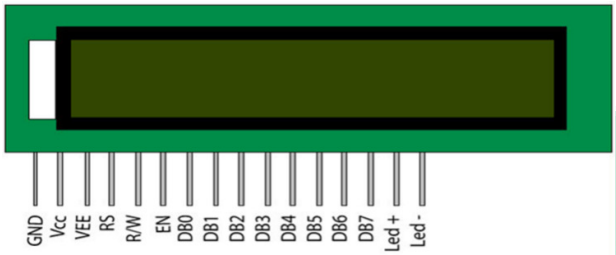



FIG :5 PIN DIAGRAM OF PIC 16F877A

In PIC16F877A there are two types of main instructions. They are RISC (reduced instruction set computing) and CISC (complex instruction set computing).It uses CMOS law. It is used for low power application.CMOS stands for Complementary MOSFET.It is the combination of two

channels namely P channel and N channel).The above fig 5 shows the various input/output ports. The types of ports include PORT A (RA0 TO RA5) is a 6 bit register, PORT B (RB0 TO RB7) is a 8 bit register, PORT C (RC0 TO RC7) is a 8 bit register,PORT D (RD0 TO RD7) is a 8 bit register PORT E (RE0 TO RE2) is a 3 bit register.

## 7. LCD MODULE




PIN DETAILS:

| PIN | SYMBOL | I/O | DESCRIPTION |
|---|---|---|---|
| 1 | VSS | _ | ground |
| 2 | VCC | _ | +5v power supply |
| 3 | VEE | _ | Power supply to contrast control |
| 4 | RS | I | RS=0 to select command register |
| 5 | RW | I | RS=1 to select data register |
| 6 | E | I/O | enable |
| 7 | DB0-DB7 | I/O | The 8-bit data bus |

LCD REGISTER:

LCD register is divided into two types namely, command register/control register and data register. Command register is instruction given to LCD to do predefined task like initialization, clearing its screen, setting cursor position, controlling display. Data register is used to store the data to be displayed in a LCD. The Attention commands can only understand the ASCII values of the character.

## 8. TIMER MODULE

In PIC16F877A there are three timer modules, namely, TIMER 0,TIMER 1,TIMER 2.In our project TIMER1 module is used because it has 16 bit registers which has two eight bit registers (TMRH and TMRL).the other two TIMERS have only 8 bit as control bit. The register pair of timer 1 module is TMRH: TMRL. It increments from 0000h to FFFFh and again roll over to 0000h.In timer 1 interrupt flag is enabled which generates an overflow which is latched in interrupt flag bit (TMRIF).The interrupt can be enabled or disabled by setting/clearing TIMER1 interrupt enable bit (TMR1E).Timer 1 module operates in two modes namely TIMER and COUNTER. The mode of operations can be determined by the BIT 0 clock select bit, TMR1CS .Timer 1 can be enabled /disabled by selecting /clearing the control bit TMR1ON bit .

REGISTER: T1CON :TIMER1 CONTROL REGISTER

| -- | -- | T1CKPS1 | T1CKPS0 | T1OSCEN | T1SYNC | TMR1CS | TMR 10N |
|---|---|---|---|---|---|---|---|

BIT 7 BIT0

| Bit | Explanation |
|---|---|
| 7-6 | Read as 0 |
| 5-4 | T1CKPS1 :T1CKPS0 : Timer1 input clock prescale select bits<br>11=1:8 prescale value<br>10=1:4 prescale value<br>01=1:2 prescale value<br>00=1:1 prescale value |
| 3 | T1OSCEN: Timer 1 oscillator enable control bit<br>1=oscillator enabled<br>0=oscillator is shutdown |
| 2 | $\overline{\text{T1SYNC}}$ : Timer 1 external clock input synchronization control bit<br>TMR1CS=1<br>1=do not synchronize external clock input<br>0= synchronize external clock input<br>TMR1CS=0<br>This bit is ignored .Timer1 uses the internal clock when TMR1CS=0 |
| 1 | TMR1CS:Timer 1 clock source select bit<br>1=External clock<br>0=internal clock (FOSC/4) |
| 0 | TMR10N: Timer1 on bit<br>1=Enable Timer1<br>0=Disable Timer1 |

TIMER 1 OPERATING IN TIMER MODE:
By clearing the TMR1CS bit the Timer mode is enabled. In this mode the clock input to the timer is FOSC/4(Frequency of Oscillation).The synchronize bit is not needed because internal clock is synchronised always.

ANALOG TO DIGIAL CONVERTER (A/D) MODULE:
It has five inputs for 28 pin devices and eight input for 40/44 pin devices.Here we are using 8 inputs as the pic controller is a 40 pin IC.The analog input is converted into 10 bit digital output. This module has high and low reference input that is software selectable to Vdd , Vss, RA2 or RA3 combination.
The A/D module has a special feature of being operated even in device sleeping mode. To operate the device in sleeping mode the A/D clock must be derived from A/D internal RC oscillator.

| ADCS1 | ADCS0 | CHS2 | CHS1 | CHS0 | GO/DONE | - | ADON |
|---|---|---|---|---|---|---|---|

BIT7 BIT0

| Bit | Explanation |
|---|---|

| | |
|---|---|
| 7-6 | ADCS1 :ADCS0:A/D conversion clock select bits<br>ADCON1=1<br>ADCON0=00(FOSC/4) |
| 5-3 | CHS2: CHS0:Analog channel select bit<br>000 = Channel 0 (AN0)<br>001 = Channel 1 (AN1)<br>010 = Channel 2 (AN2)<br>011 = Channel 3 (AN3)<br>100 = Channel 4 (AN4)<br>101 = Channel 5 (AN5)<br>110 = Channel 6 (AN6)<br>111 = Channel 7 (AN7 |
| 2 | GO/DONE:A/D Conversion status bit<br>ADON=1<br>1=A/D conversion is in process<br>0= A/D conversion is not in process |
| 1 | Read as 0 |
| 0 | ADON:A/D on bit<br>1=A/D converter module is powered up<br>0=A/D converter is shut down |

ADCON1 REGISTER:

| ADFM | ADCS | -- | -- | PCFG3 | PCFG2 | PCFG1 | PCFG0 |
|---|---|---|---|---|---|---|---|

BIT 7 BIT0

| Bit | Explanation |
|---|---|
| 7 | ADFM:A/D Result format select bit<br>1=right justified (most significant bit read as 0) socket.<br>0=Left justified (least significant bit read as o) |
| 6 | ADCS2:A/D Conversion clock select bit |
| 5-4 | Read as 0 |
| 3-0 | PCFG3:PCFG0:A/D port configuration control bits |

## 9. GSM MODULE

GSM means Global System for Mobile. It works on frequencies of 850MH, 900MHz, 1800MHz, 1900MHz.Its size is too compact and it is used to plug in GSM modem easily. This modem is designed with 3.3V and 5V DC TTL interfacing circuit, which helps us to interface with 5V micro controllers. By the use of Attention commands. The baud rate can be varied from 9600 to 11500 bps.By using the GPRS feature, we can access the internet also.GPRS means General Packet Radio Service. It is used for sending the SMS and also for data transfer application through the interface of mobile phone to mobile phone.

WORKING:

To works the device on TTL logic, MAX 232 is used. It is an integrated circuit which converts the signals of RS232 port to suitable signals. So that we can share the data with devices which is connected through serial port. We can provide the voltage upto 12V AC/DC through power supply GSM includes LM317 voltage regulator which gives an output voltage ranges from 1.2V to 37V.There are 3 pins such as RXD, TXD, GND pins which are used to connect the devices to GSM module through USART(Universal Synchronous Asynchronous Receiver and Transmitter Communication) to transmit and receive the data. Audio connectors are used for audio related operations. Through the pins of Audio connectors we can give input and get output while calling using microphone or speaker. The sim card must be inserted to the sim card holder. The fault occurs on the system which is detected through PIC controller by Attention commands is sent to the GSM module. LEDs are provided to indicate the status regarding the fault. By obtaining this the sim card will generate the message regarding the fault to the operator.

## 10. LM35 SENSOR

FIG :6 LM35 SENSOR

LM35 is a precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to Celsius temperature. It is calibrated directly into ° Kelvin. It does not need external calibration to provide accuracy of ±1.4°C at room temperature and ±3.4°C over a full -55 to +150°C temperature range .the fig 6 shows the picture of LM35 sensor .It has a accuracy of 0.5°C and which is suitable for remote applilication.LM35 operates from 4 to 30 volts and less than 60 μA current drain and which has low impedance output.

## 11.CONCLUSION

All the units are switched on and off with the use of the microcontroller program. so a lot of man power is reduced in BHEL saving them a cost of more than ten lakhs per annum. with the use of the GSM modem the time of the operator is also consumed. the operator need not check the units periodically. He will receive messages incase of fault conditions and temperature exceedance. so a lot of time, manpower and cost is reduced with this model