THREE PHASE STAR-DELTA MOTOR SATRTER

A Major Project Report

Submitted in Partial Fulfillment of the Requirements for the Degree of

BACHELOR OF TECHNOLOGY

IN

ELECTRONICS & COMMUNICATION ENGINEERING

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13BEC029

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TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Mr. Prashant S. Gandhi** student of B.Tech. Electronics and Communication Engineering of Nirma University Institute of Technology. Ahmedabad has completed the industrial project entitled **"Three Phase Star-Delta Control Panel"** at GELCO ELECTRONICS Pvt. Ltd., Ahmedabad, from the time period of 9th January 2017 to 30th April 2017. During the period of his internship programme with us, he was found punctual, hardworking and inquisitive.

We wish him success in all future endeavors.

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I would like to show my gratitude towards our esteemed Prof. Jayeshkumar Patel. He plays the role of boosting confidence confining to our project on. Apart I would also thank GELCO ELECTRONICS PVT. LTD. for helping me solving all the obstructions that I faced during making of this project training. At last I would also pay my attention to all resources that I could gather on due time for doing the project under the guidance of my manager Mr. Ravi Vadadoriya. So I thank all of them for completing the training and achieving the deadline well in advance.

ABSTRACT

It is always said that "Precaution is better than cure". Provide protection to any equipment is very important especially when these equipment's are used in industries or in agriculture because they are very expensive and their repairing also expensive. Sometimes when motors are running on overload, windings of copper in motors get burn and motors get damage. Also if there is imbalance between lines voltage in three phase it damages motors. So to avoid such problems today all industries and agriculture sectors provide protection to their motors. In industries and in agriculture generally three phase motors are used. In three phase motors Star-Delta connection is used because in these type of connection current is reduced by 3-4 times of the direct current and because of it voltage also reduces and it causes less losses. In this project High-Voltage protection, Low-Voltage protection, Overload Protection, Dry run protection, unbalance voltage protection are given. This project uses pic microcontroller to provide all above features. Also we can also set current range (2-20 Amp) as application demand. To show lines voltages, currents and faults this project uses 16x4 LCD.

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Chapter 1

Introduction

1.1 Three-Phase Power

Phase- In electronic and electrical signaling, phase can be defined as position of a point at any instant time on a wave cycle. A complete cycle is defined as 360 degree of phase as shown in figure-1.1. Phase can be also expression of relative displacement between or among waves having same frequency. [1]

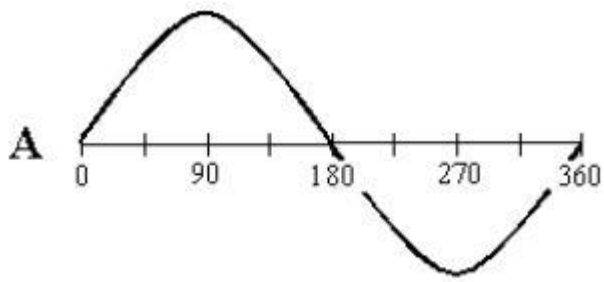

Figure-1.1 Waveform

Phase difference, also called phase angle, in degrees it is usually defined as a number greater than -180, and less than or equal to +180. Leading phase denotes to a wave that occurs "ahead" of another wave of the same frequency. Lagging phase denotes to a wave that occurs "behind" another wave of the same frequency. When two signals vary in phase by -90 or +90 degrees, they are called in phase quadrature. When two waves vary in phase by 180 degrees though -180 is technically the same as +180, the waves are called in phase opposition. Figure-1.2 shows two waves that are in phase quadrature. The wave represented by the dashed line leads the wave represented by the line by 90 degrees. [1]

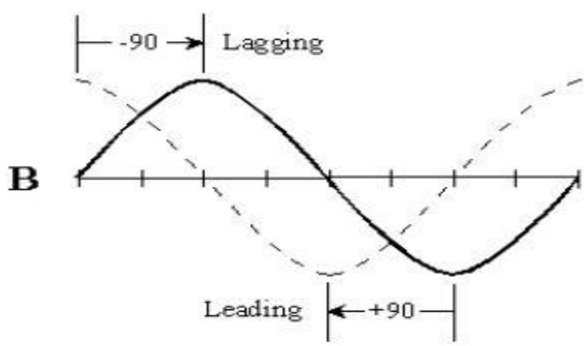

Figure-1.2 wave representing concept of leading and lagging

In electrical domain 2 types of systems are used, one is Single-Phase systems which uses single phase power supply and second is Three-Phase systems which uses Three-Phase power supply. To understand the electrical power, one should first understand Single-phase power and Three-phase power distribution. We can understand it in very simple way, most homes are wired with single-phase which contain two hot-wires which carry AC voltages and one is neutral. Dual phase or split phase also comes under single phase. Voltage across two hot wires in single phase measures 240 VAC (for oven and dryer) and across any hot to neutral measures 120 VAC (for everything else). Figure 1.1 is single phase. In industries and agricultures three-phase wiring is used which consists of three ac voltages separated from each other by 120 electrical degree or by a third of a cycle. These system deliver power over three lines in which between any two lines voltage measures 208 VAC. Another way to look at three-phase power is combination of three single phase power that deliver power in way that it never falls to zero, meaning that load is constant at any instant due that it is ideal for motors which are used in Industries and Agriculture. It eliminates the need for starting capacitor. It also allows for smaller wires (i.e., less copper) and lower voltages for the same power transmission as single-phase, making it less expensive and safer.

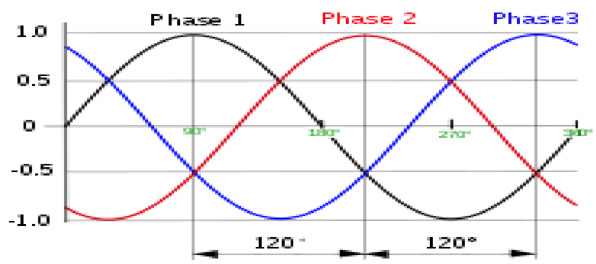

Figure-1.3 Three-phase power

1.2 Star-Delta Connection

In three phase motors star-delta star is most commonly used connection as compared to any other connection. It is normally used for motors which are designed to run on the delta connected starter winding. The connection of three phase induction motor with star-delta connection is shown in figure-1.4. From the figure we can see that when switch is in START position starter windings are connected in star connection as shown in figure 1.5. When motor pick up the speed 80 percentage of rated speed it switch over to delta connection meaning switch immediately put in the RUN position and windings are connected to delta connection as shown in figure-1.6. First, the stator winding is connected as star and the as delta which helps to reduce lines currents one-third of the direct currents. Due this at the starting of induction motor when it is connected in star each stator phase gets a voltage of $\frac{V_L}{\sqrt{3}}$ where, V_L is Line voltage.

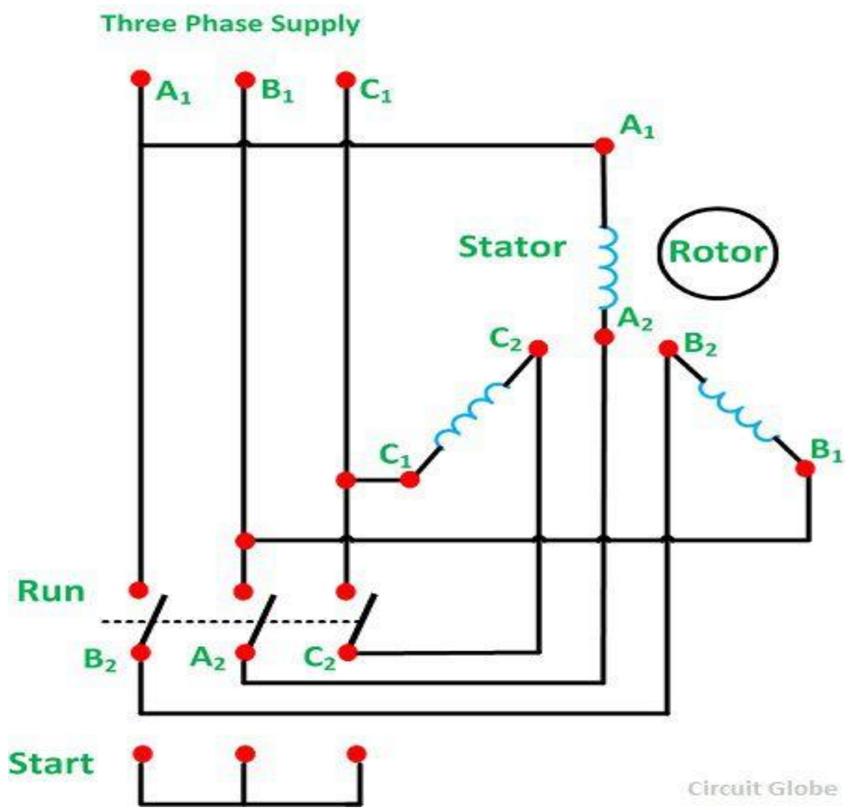

Figure-1.4 Star-Delta Connection

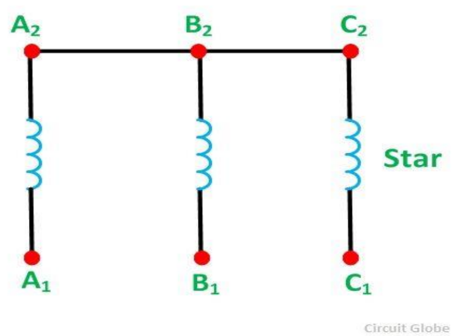

Figure-1.5 Star connection

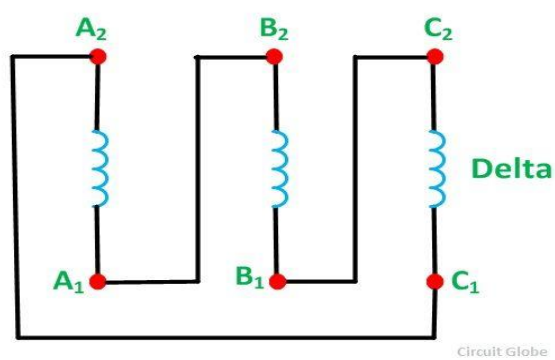

Figure-1.6 Delta connection

1.3 Features of the Project

Features of three phase star-delta motor starter is listed below.

I. Microcontroller based technology- In this project pic microcontroller is used which allow us to make this project more flexible.

II. 16x4 LCD- This will help us to keep watch on voltages and currents in lines and it will help to recognize the type of faults.

III. High-Voltage protection- Whenever voltages in lines are above 480 VAC it will shut the motor and display High Voltage on LCD.

IV. Low-Voltage protection- Whenever voltages in lines are below 220 VAC it will shut the motor and display Low Voltage on LCD.

V. VSP (Voltage Single Phasing) - Whenever voltages unbalances occur it will display VSP on LCD and motor will be shut down.

VI. Overload protection- Whenever motor will run over its full load capacity it will display Overload on LCD and it will stop the motor.

VII. Dry run protection- Whenever motor will run without any load it will display Dry run on LCD and it will stop the motor.

1.4 Application

Three phase star-delta motor starter is used for protection of motors in industries and agriculture. It gives protection over high voltage, low voltage, overload, dry run, voltage unbalance. It can be used with any three phase motors and pumps.

1.5 Manufacturing Process

I. Research & Development- In this section all the features are decided, microcontroller selection and its programming is done. Also circuit designing and PCB layout are also made here.

II. PCB assembly- In this section component's mounting is done using axial component machine and Radial component machine. Using bath soldering machine soldering of components on PCB are done. Finally, if there any fault in soldering done by machine manual soldering is done.

III. Assembly section- In this section for a particular product different PCBs are assembled here and packaging is done. After that testing of that final good is done. If it is working good then it is ready for the market, otherwise it is sent to R&D department where their faults are get corrected.

Chapter 2

Hardware Portion

2.1 Block Diagram

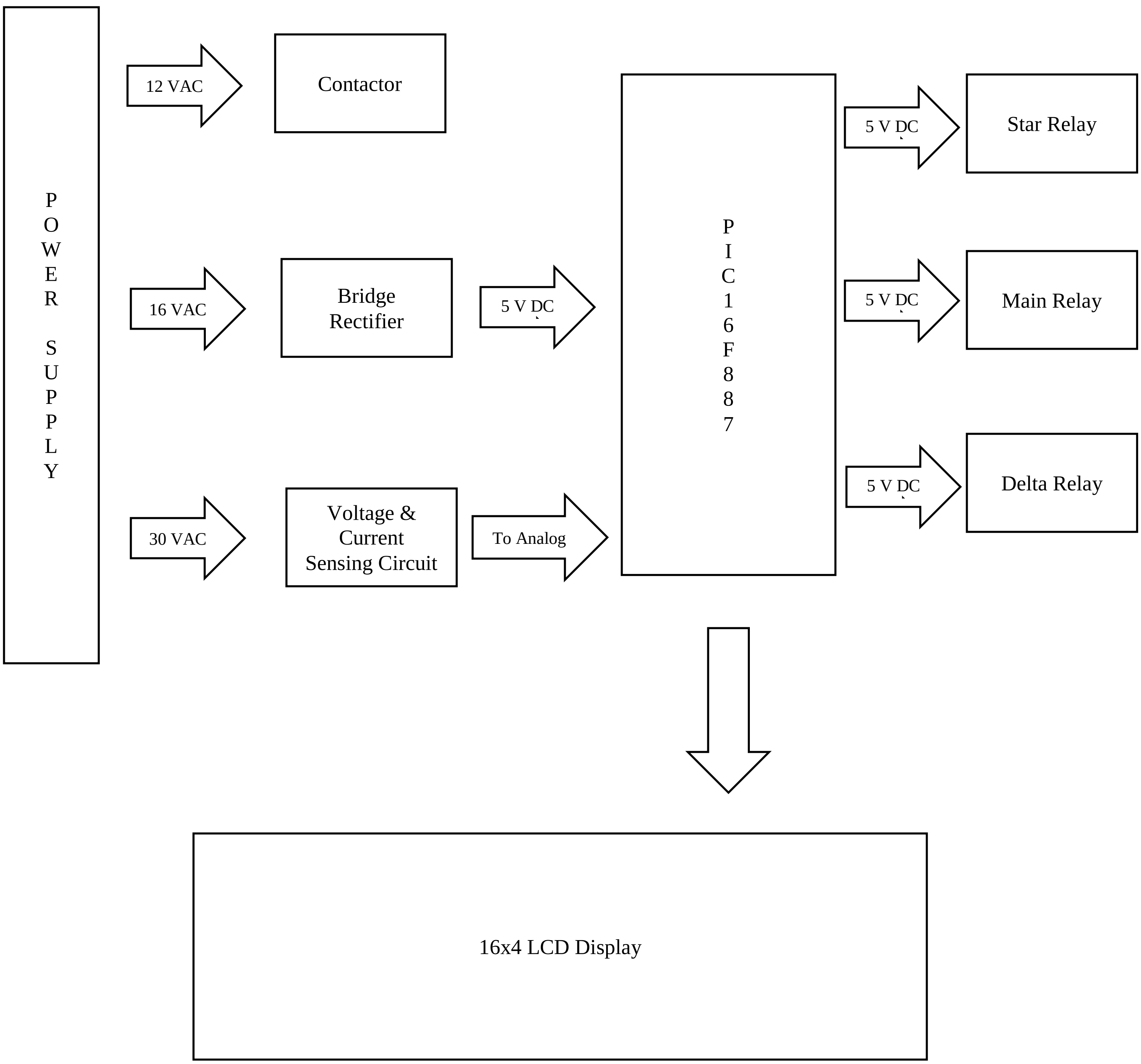

Figure-2.1 Block Diagram

2.2 Power Supply

We are using transformer based power supply in this project. At primary side we give 0-500 VAC frequency 50 Hz and at secondary we side three coils will be there. In first coil we get 12 VAC, from this we generate 5 V dc for the microcontroller and any other hardware part which required 5 V dc. From second coil, we get 16 V ac. From secondary coil we will operate replays of star, delta and main. From third coil which produces 30 V ac, we use this for voltages and currents measurement from the line. As we discussed in introduction part there are three replays, one is star relay, second is delta relay, and third one is main relay. When we on the unit first star relay will be operated. After few milliseconds main relay will get start. After 5-10 seconds we disconnect star relay and switch over to delta relay. During switch over main relay will be always connected.

2.3 Contactor

When a relay is used to switch a large amount of electrical power through its contacts, it is labelled by a special name: contactor. Contactors characteristically have several contacts, and those contacts are usually (but not always) normally-open, so that power to the load is shut off when the coil is de-energized. The most common industrial use for contactors is the control of electric motors.

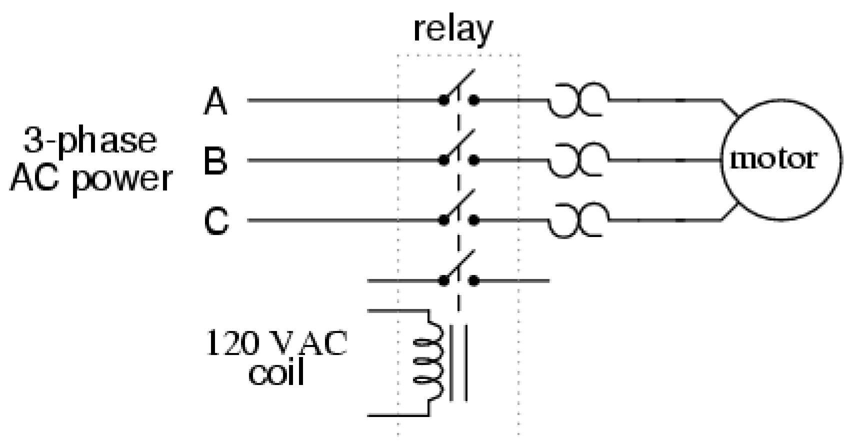

Figure-2.2 Contactor

A contactor is an electrically controlled switch used for switching an electrical power circuit, similar to a relay except with higher current ratings and a few other differences. A contactor is controlled by a circuit which has a much lower power level than the switched circuit.

Contactors are coming in many forms with varying capacities and structures. Contrasting a circuit breaker, contactors are not intended to interrupt a short circuit current. Contactors range from those having a breaking current of several amperes to thousands of amperes and 24 V DC to many kilovolts. The physical size of contactors ranges from a device small enough to pick up with one hand, to large devices approximately a meter on a side.

2.4 PIC microcontroller

Main feature of this starter is that it is microcontroller base technology. In this project we are using PIC16F887 microcontroller and we are using below features of this microcontrollers for our project.

I. Personal Internal Oscillator- Software selectable frequency range of 8 MHz to 31 MHz.

II. Brown-out-reset(BOR) with software controllable option

III. Enhanced low-current watchdog timer with on chip oscillator with software enable

IV. Programmable code protection

V. A/D Converter- 10-bit resolution and 14-channel

VI. Three timers- Timer0- 8-bit timer/counter with 8-bit programmable presaler

Timer1- 16-bit timer/counter with programmable prescaler,

External gate input mode,

Dedicated low-power 32 KHz oscillator

Timer2- 8-bit timer/counter with 8-bit period register, prescaler, and postscaler.

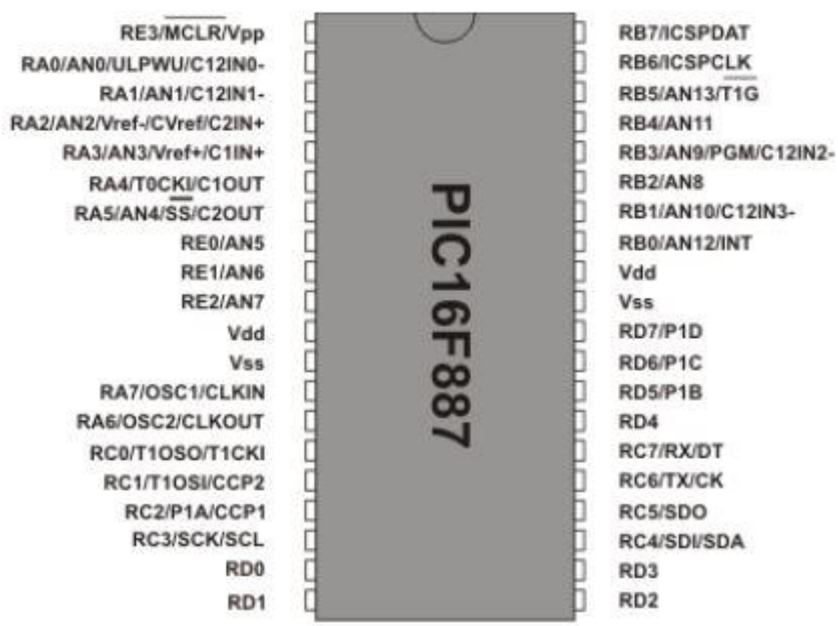

Figure-2.3 PIC16F887 microcontroller

2.5 16x4 LCD

16x4 means it contains 16-columns and 4-rows. Its pin out diagram is similar to that of 16x2 LCD as shown below. First two pins are ground and VCC also labeled as VSS and VDD for providing power to 16x4 LCD display. 3rd pin is VEE which controls the contrast of the LCD display. A 10 KΩ potentiometer whose fixed ends connect to VDD, VSS and variable end connect to VEE can be used to control contrast of the LCD otherwise we can directly connect it to ground. A microcontroller needs to send two types of information for operating LCD Module, Data Information and Command Information. Data Information is the ASCII value of the characters to be displayed in the LCD display and Command Information controls other operations such as position to be displayed, clear screen, right shift, left shift. Data and Command Information are sent to LCD through data lines DB0 – DB7 which are multiplexed using RS (Register Select) pin of LCD. When RS is HIGH meaning 1 LCD treats DB0 – DB7 data pins information as Data to be displayed and when it is LOW meaning 0 LCD treats it as Command Information. Enable (E) input of the LCD is used to give Data Strobe. HIGH (5V) Voltage Level in the Enable (E) pin tells the LCD that DB0 – DB7 contains valid information. The input signal R/W (Read or Write) determines whether data is written to or read from the LCD. In normal cases we need only writing hence it is tied to GND in circuit shown below.

Figure-2.4 16x2 LCD

We can interface this LCD with microcontroller using two modes. First, we can interface it with 8-bit mode and second using 4-bit mode. Generally we use 4-bit mode to save microcontroller pins and also microcontroller frequency is so high that human eye cannot detect any delay.

2.6 List of Components

Table-2.6 List of Components

Components Name	No. of Components	Value
Resistor	15	100K
Resistor	3	8.2K
Resistor	3	47K
Resistor	6	10K
Resistor	3	22
Resistor	3	4.7K
Potentiometer	2	1K
Diode	3	1N4007
16x4 LCD	1	NA
PIC16F887	1	NA
Transistor	3	TCD-100
Contactor	3	NA
7805	1	NA
Ceramic Capacitor	6	104
Relay	3	NA

Chapter 3

Software Portion

3.1 MPLABX

MPLAB X IDE is software program available on PC which allows developer to develop application for the pic microcontrollers and digital signal controllers. It is an Integrated Development Environment (IDE) because it gives single integrated “environment” to develop code for embedded application. It is an open source software and is develop on the NetBeans platform. It uses XC8 compiler which gives good optimization of the code. XC8 compiler is for 8-bit PIC devices.

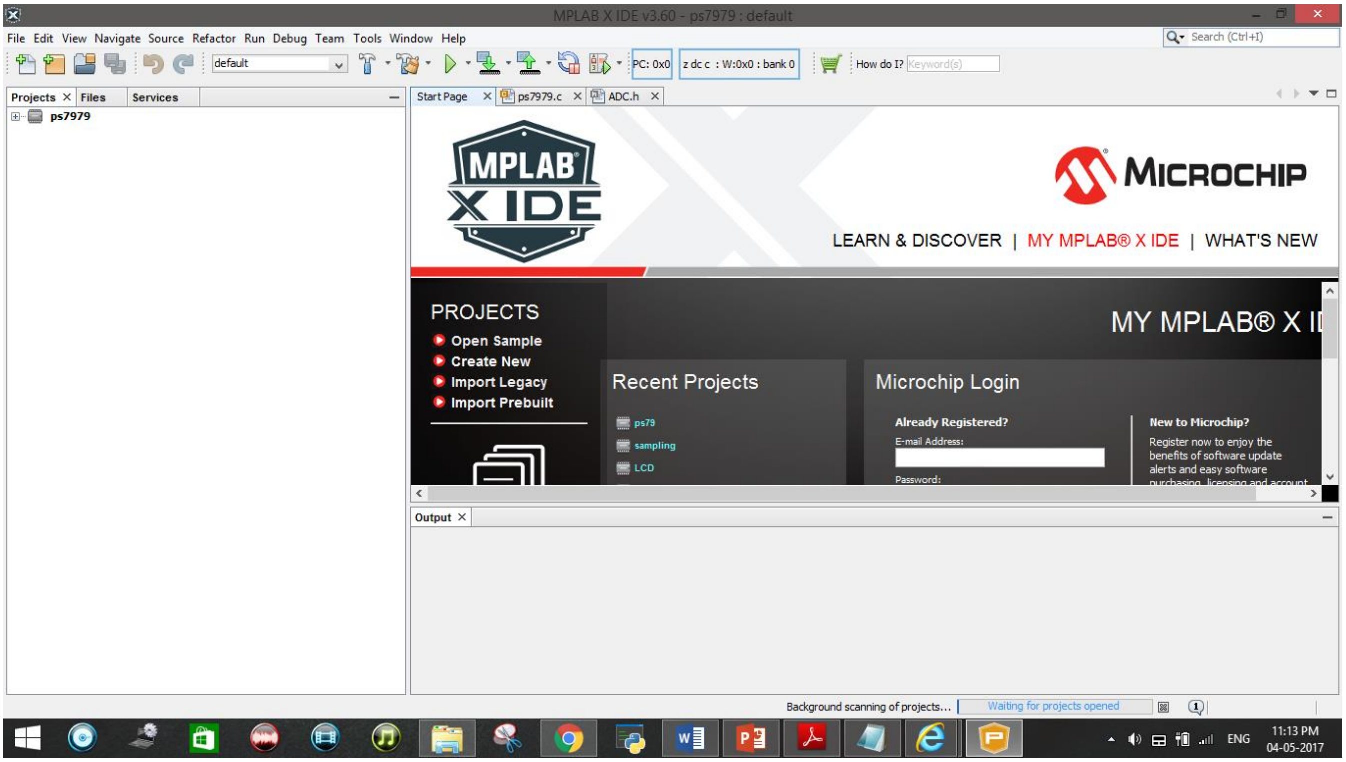

Figure-3.1 MPLAB X starting page

3.2 Header File for 16x4 LCD

Register of LCD is shown below which is used to create header file for LCD. Writing values into that register we can make header file for LCD very easily.

Flow-chart of the header file is shown in figure-3.3

Instruction	Instruction code										Description	Execution time (fosc= 270 KHZ
	RS	R/W	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
Clear Display	0	0	0	0	0	0	0	0	0	1	Write "20H" to DDRA and set DDRAM address to "00H" from AC	1.53ms
Return Home	0	0	0	0	0	0	0	0	1	-	Set DDRAM address to "00H" From AC and return cursor to Its original position if shifted. The contents of DDRAM are not changed.	1.53ms
Entry mode Set	0	0	0	0	0	0	0	1	I/D	SH	Assign cursor moving direction And blinking of entire display	39us
Display ON/ OFF control	0	0	0	0	0	0	1	D	C	B	Set display (D), cursor (C), and Blinking of cursor (B) on/off Control bit.	
Cursor or Display shift	0	0	0	0	0	1	S/C	R/L	-	-	Set cursor moving and display Shift control bit, and the Direction, without changing of DDRAM data.	39us
Function set	0	0	0	0	1	DL	N	F	-	-	Set interface data length (DL: 8-Bit/4-bit), numbers of display Line (N: =2-line/1-line) and, Display font type (F: 5x11/5x8)	39us
Set CGRAM Address	0	0	0	1	AC5	AC4	AC3	AC2	AC1	AC0	Set CGRAM address in address Counter.	39us
Set DDRAM Address	0	0	1	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Set DDRAM address in address Counter.	39us
Read busy Flag and Address	0	1	BF	AC6	AC5	AC4	AC3	AC2	AC1	AC0	Whether during internal Operation or not can be known By reading BF. The contents of Address counter can also be read.	0us
Write data to Address	1	0	D7	D6	D5	D4	D3	D2	D1	D0	Write data into internal RAM (DDRAM/CGRAM).	43us
Read data From RAM	1	1	D7	D6	D5	D4	D3	D2	D1	D0	Read data from internal RAM (DDRAM/CGRAM).	43us

Figure-3.2 LCD registers

DISPLAY CHARACTER ADDRESS CODE

Display Position	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
DD RAM Address	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
DD RAM Address	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F
DD RAM Address	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
DD RAM Address	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F

Figure-3.3 16x4 Display Character Address code

By knowledge of address and LCD register we can easily design command to set the cursor on the screen. For more detain knowledge one can always refer to LCD datatsheet.

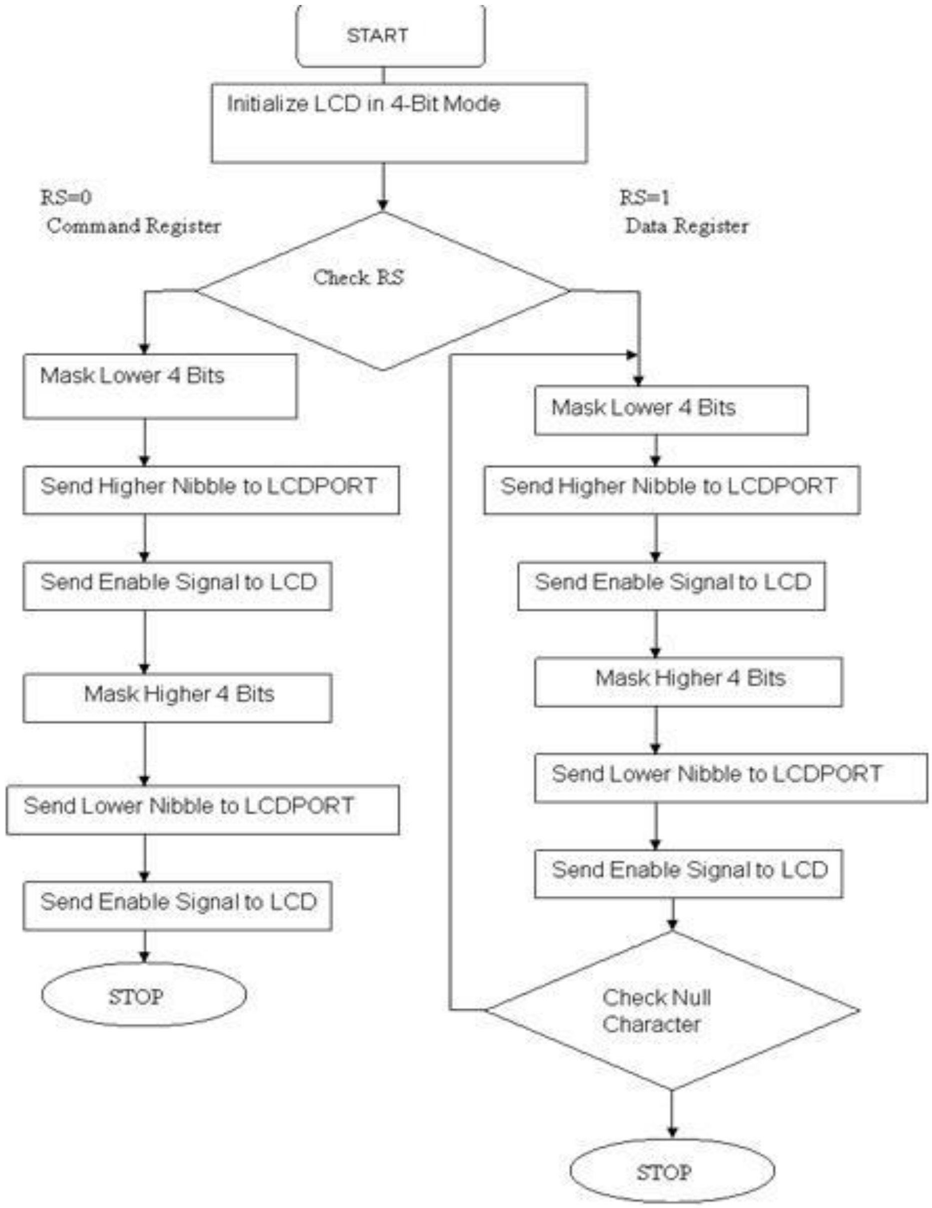

Figure-3.4 Flow chart for LCD

3.3 ADC.H Header File

Flow-chart to create ADC header file is as below.

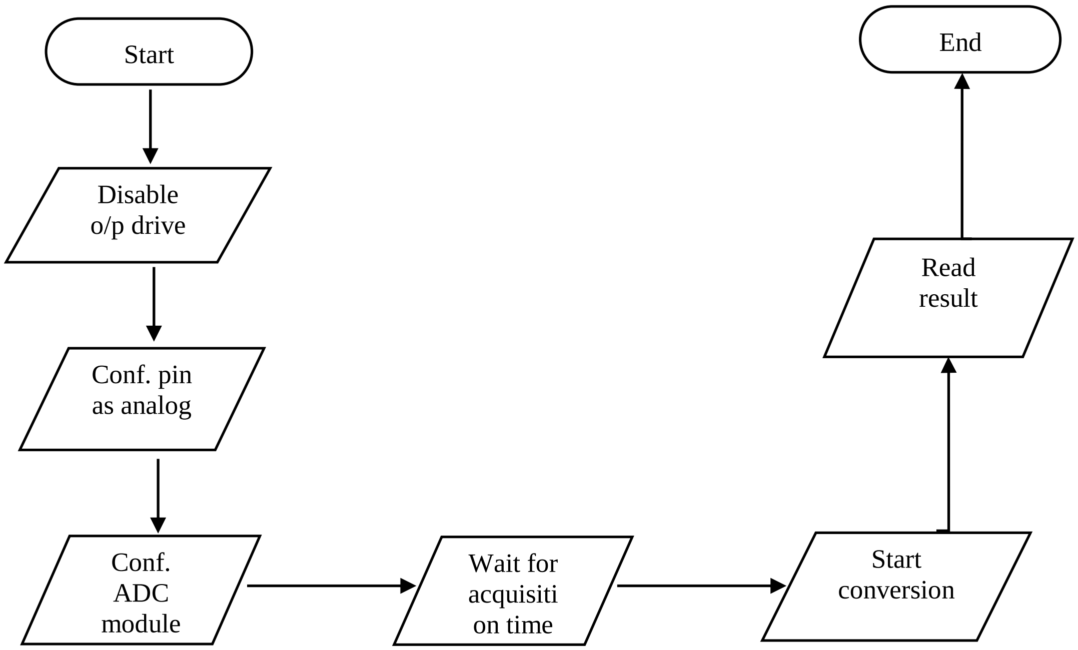

Figure-3.5 ADC flow-chart

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
ADCS1	ADCS0	CHS3	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	ADON
bit 7							bit 0

Figure-3.6 ADC control register 0

I. ADCS<1:0> : ADC conversion clock select

II. CH<3:0> : Analog channel select

III. GO/DONE : A/D conversion status bit

IV. ADON : ADC enable bit

R/W-0	U-0	R/W-0	R/W-0	U-0	U-0	U-0	U-0
ADFM	—	VCFG1	VCFG0	—	—	—	—
bit 7							bit 0

Figure-3.7 ADC control register 1

I. ADFM : A/D Conversion result format select bit

II. VCFG : Voltage reference bit

Acquisition time- For the ADC to meet its specified accuracy, the charge holding capacitor (CHOLD) must be allowed to fully charge to the input channel voltage level. Time to charge this capacitor is called acquisition time. We must have to wait for accurate ADC conversion.

3.4 Main.c Flow-Chart & Calculation

Timer 0

The Timer0 module timer/counter has the following features:

I. 8-bit timer/counter
II. Readable and writable
III. 8-bit software programmable prescaler
IV. Internal (4 Mhz) or external clock select
V. Interrupt on overflow from FFh to 00h
VI. Edge select (rising or falling) for external clock

Timer0 has a register called TMR0 Register, which is 8 bits of size. Desired values can be written into the register which will be increment as the program progresses. Frequency can be changed depending on the Prescaler. Maximum value which can be allocated to TMR0 register can be 255.

MR0IF - TMR0 Overflow Interrupt Flag bit. When the TMR0 register overflows from FFh to 00h The TMR0 interrupt generated. This overflow sets bit TMR0IF (INTCON<2>). Developer can reset the value of this register to whatever it wants (not necessarily "0"). The value of the register TMR0 can be read and write into by developer. Its values can be read by developer at any moment or it can check if there are certain numeric values that it needs.

Prescaler - Frequency divider.

We can use Prescaler for further division of the system clock. The options are:

I. 1:2
II. 1:4
III. 1:8
IV. 1:16
V. 1:32
VI. 1:64
VII. 1:128
VIII. 1:256

The formula for the 8-bit timer 0's period is as below

$T_t = (256 - TMR0) * \frac{4*PS}{Focs} + X*\frac{4*PS}{Focs}$

Above formula is the number of timer clock ticks obligatory for the timer to expire. Since this microcontroller has an 8-bit timer (Timer 0), the timer will be overflow at 256. Hence, the number of ticks is the difference between the value encumbered in the TMR0 register and 256. Similarly if there is a 16-bit timer (Timer 1), the TMR1 register is actually a couple of 8-bit registers (TMR1H:TMR1L). In such case, the formula will become (65536-TMR1H:TMR1L) where TMR1H:TMR1L is the 16-bit value encumbered into the register pair. This will lengthen the time of a single timer clock tick. The frequency of the timer clock is Fosc/(4*PS) where Fosc is the oscillator clock speed (4 MHz by default) and PS is the pre-scalar designated. If developer is using an external clock on the T0CKI pin (T0CS = 1), the frequency will be simply the value for that clock source.

This is the synchronization delay for Timer 0. This is because of the circumstance that the TMR0 incrimination are disabled for two instruction cycles after being written. Also we also consider the number of timer cycles that will be missed during this time so for that there is factor x. If developer is using the system clock with the timer and its pre-scalar will be set for 1:1, x is 2. This is due to the timer clock will be at the same speed as the instruction clock, and thus the first 2 pulses will be failed to increment the register. If developer's pre-scalar is set to 1:2, x is 1 because only the first clock pulse will arrive during the delay phase. If the pre-scalar is set to 1:4 or greater, x is 0 because by the time the first timer clock pulse comes in, the incrimination is already active for the TMR0 register.

For example, for creating 1 ms delay using timer 0 calculation is as below.

TMR0 = 256 – (timerperiod*Fosc)/(4*prescaler) + X

Where, timeperiod = 0.001s,

Fosc = 4000000,

Prescaler = 4,

X = 0 ,

So, TMR0 = 256 -40008/16

TMR0 = 6.

To measures voltages and currents from lines we connect each R, Y, B lines with microcontroller analog pins. Then, we take samples at every 1 ms and do summation of that. After taking 30 to 50 samples we do averaging of it. Main reason to do so is that voltages and currents in lines are instantaneous due that it will change rapidly on LCD and we cannot decide actually how much voltages and currents are there in lines. In this project, we are also giving the feature of settable current rage which is 2 to 20 amps. Calculation for converting A/D reading to voltages and currents are as below.

Calculation to convert A/D reading to Voltage,

$$\frac{Resolution\ of\ ADC}{System\ Voltage} = \frac{ADC\ Reading}{Analog\ Voltage\ Measured}$$

PIC16F887 has 10-bit ADC. ADC reports a ratio metric value. This means that the ADC assumes 5V is 1023 and anything less than 5V is between 0 and 1023.

$$\frac{Resolution\ of\ ADC}{System\ Voltage} = \frac{ADC\ Reading}{Analog\ Voltage\ Measured}$$

Flow-Chart

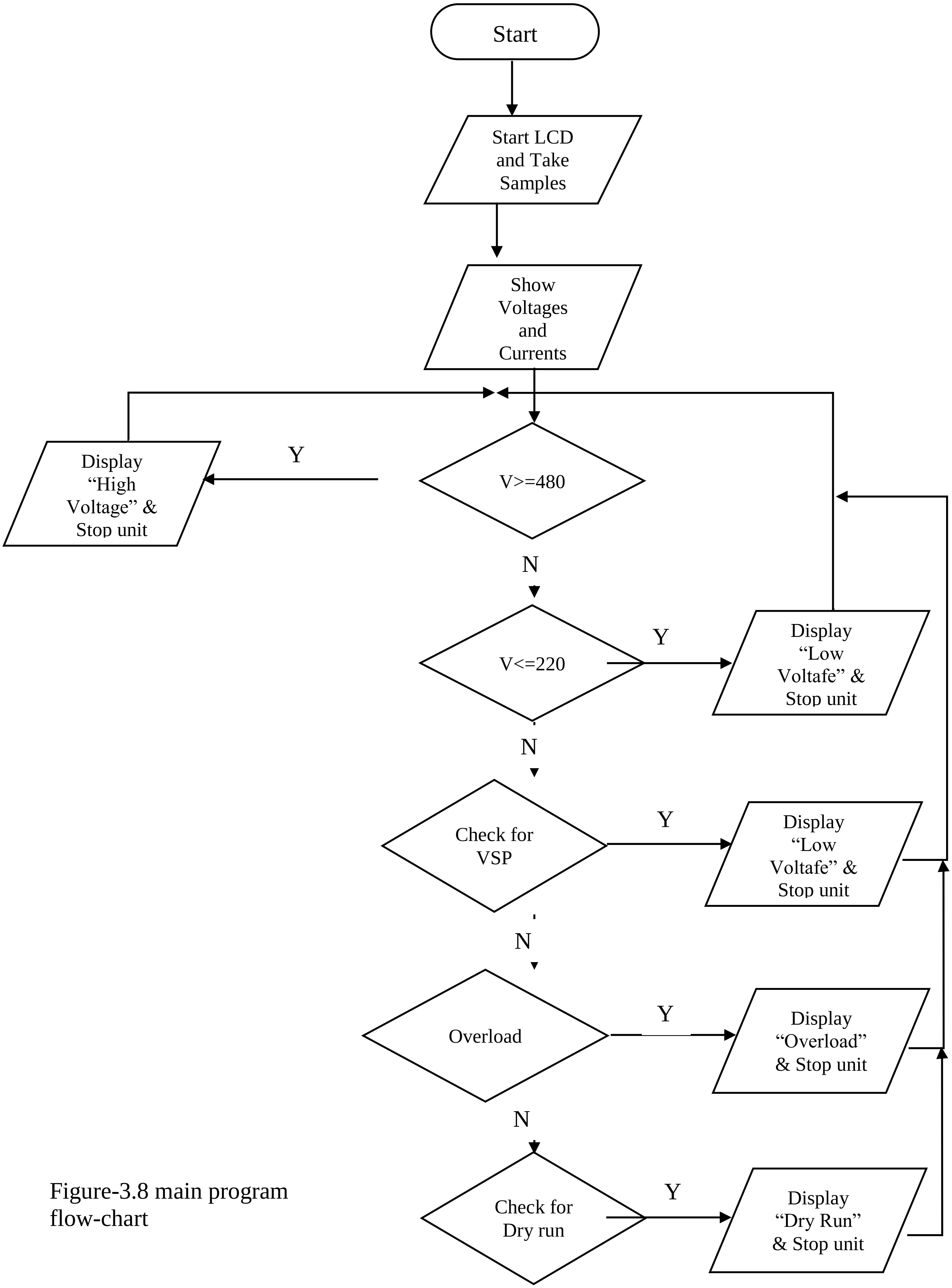

Figure-3.8 main program flow-chart

Chapter 4

Simulation Results

4.1 Voltage Measurement

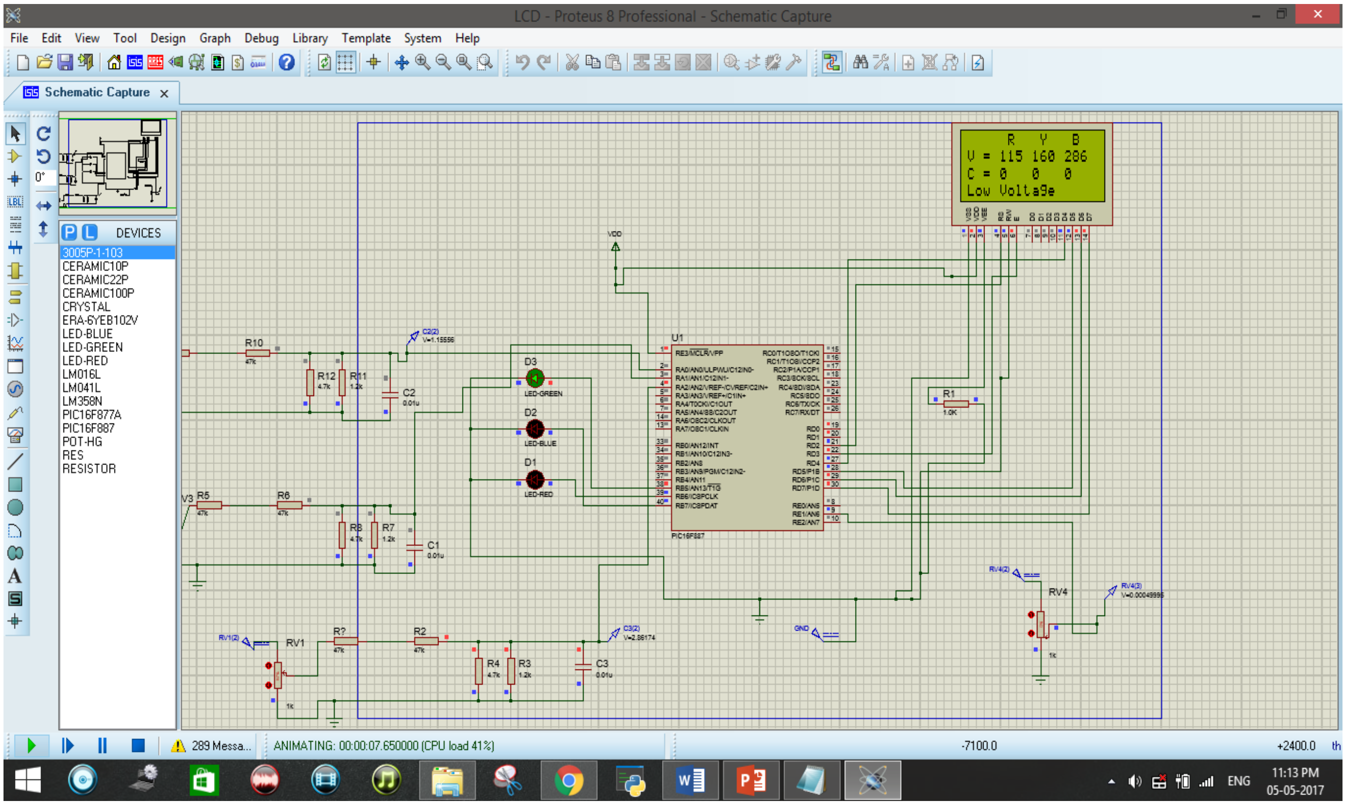

Figure-4.1 Voltage measurement

4.2 Current measurement

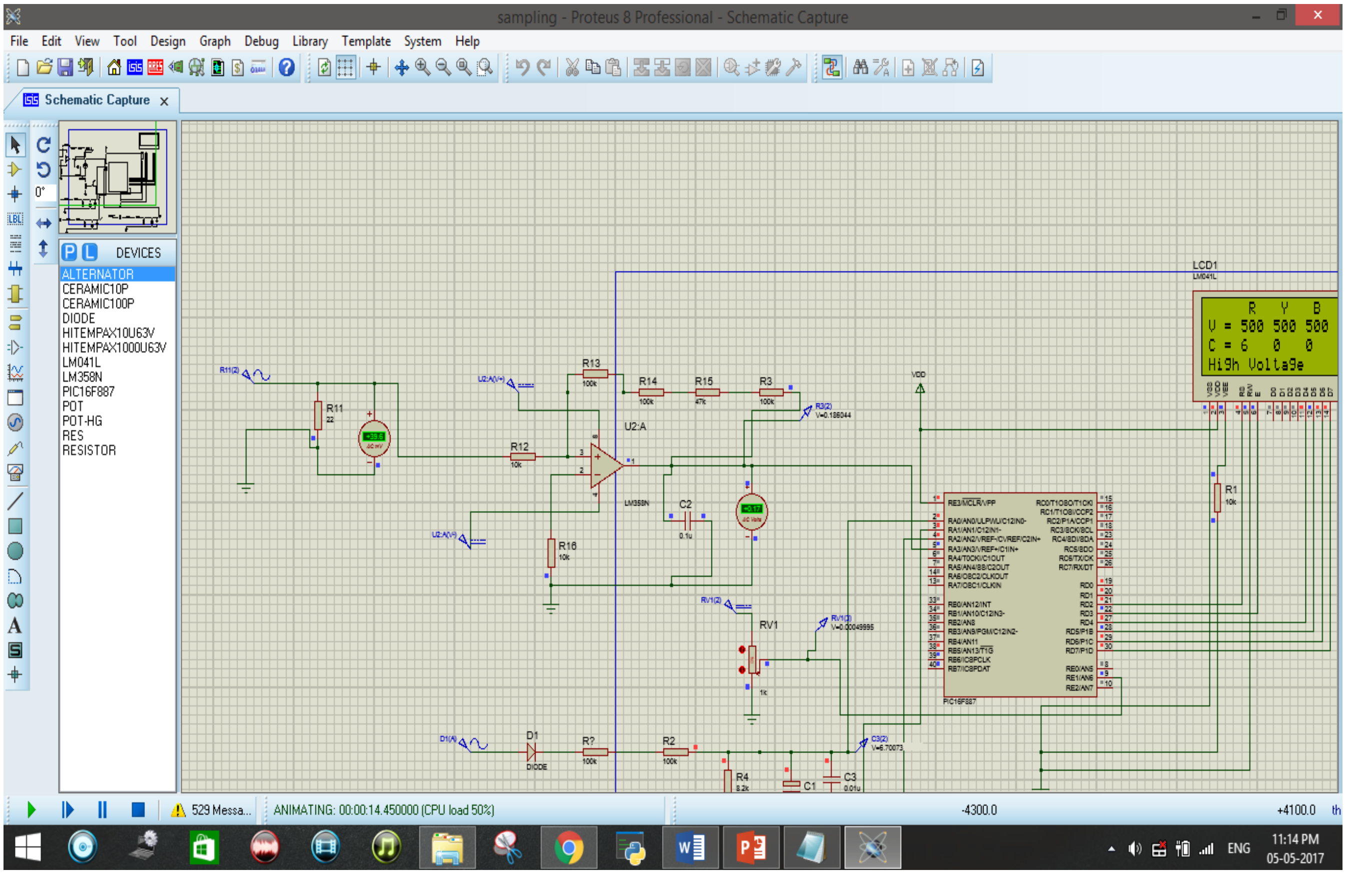

Figure-4.2 Current measurement

Conclusion

Motors use in industries and agriculture are very expensive. Giving protection to these motors and pumps are very necessary. This three phase star-delta motor starter not only give protection from the high voltage, low voltage, VSP, Overload and dry run, but also allow us to see which type of fault occur during the failure. Also we can constantly monitor voltages and currents that are coming from lines using LCD. We can also set overload and dry run features manually.

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