POWER FACTOR CORRECTION USING PIC MICROCONTROLLER

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Abstract : **Active Power Factor correction is very important factor variable load demand. PIC Microcontroller 16F177A is used for achieving good PF. The Proposed methodology is based on SPWM technique. Implemented results are shown in this paper. This scheme can be utilized in machine machines, little cranes, lifts and so forth, which are as often as possible turned ON and OFF. Along these lines the proposed scheme is an interdisciplinary methodology for mechanical, chemical, or paper enterprises, where power factor assumes a crucial job.**

IndexTerms **– Zero Crossing Detector (ZCD), Power Factor Correction (PFC), Sinusoidal Pulse Width Modulation (SPWM)**

INTRODUCTION

Zero-intersection distinguishing system is connected to the detected signs. Utilizing an explicit plan circuit, zero intersection can be detected. Fig 1.1 demonstrates the zero-intersection finder circuit (ZCD). At the point when input voltage is too low, notwithstanding, such plan can't matter and the yield beats will in general be twisted. In the wake of testing the real yield, the bending has been seen in the yield. High info voltage are worthy which is alarming voltage by the chip input pins, the extent that PIC chip is inside 1W control dissemination.

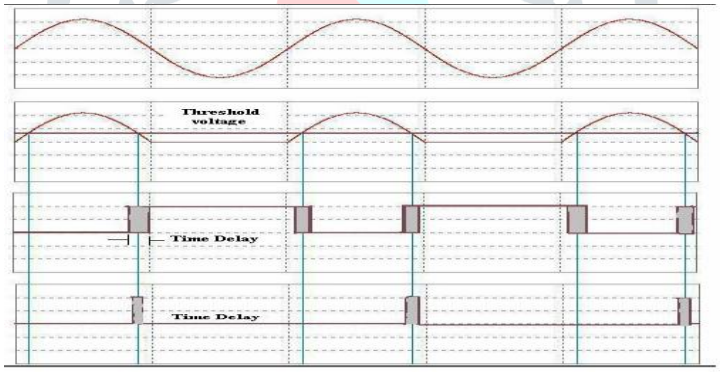

Fig 1.1 Zero-crossing detecting waveform using PIC

With the end goal to guarantee low current supply into a stick, a high outer resistor must be set before it. As indicated by the reference edge voltage, a square wave yield is then created. The product makes an interfere, when an ascent flag is identified and specifically store into the RAM for stage point estimation. At last when the catch of intrude on works like a heartbeat created and the waveform cross beneath the limit voltage. The by and large different process will surely include delay inside the framework. In any case, little postponement have and would not influence upon the real unique perusing.

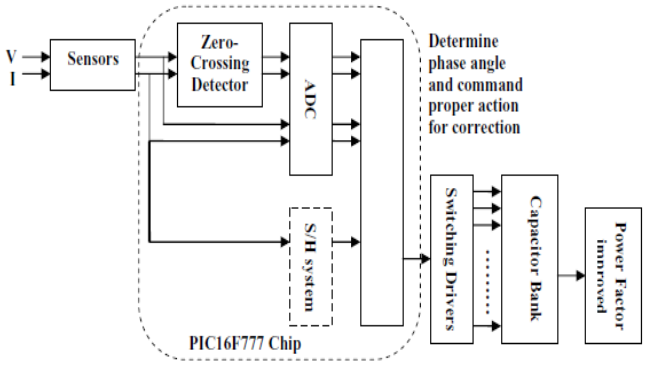

Fig 1.2 Overview of System design

Harmonic Problem

With the ascent in decent variety of intensity electronic gadgets, much consideration and concern has been given to level of music. The music is not straightforwardly caused because of capacitors. Nonetheless, with increment in recurrence, the capacitor impedance drops and prompts age of sounds. This influences the size of voltages and flows inside the transports of microcontrollers. The impact is particularly noticeable when capacitor banks are associated between the circuit and earth.

As the supply frequencies are institutionalized to be steady 50 Hz, or 60 Hz, the power factor rectification is required as an answer for such system working at a settled recurrence. Expansion of capacitor in parallel to the heap is the main key arrangement in such circumstances. A considerable measure of intensity frameworks, particularly electronic built hardware, usually utilize capacitors inside them. Capacitors however regular in gadgets, their significance as one most imperative part for power framework, is slightest comprehended by lion's share. The capacitors are ordinarily utilized in the, direction or enhancement, decrease of framework misfortune decrease of kVAR age prerequisites and arrival of framework limit in voltage.

Just least measure of upkeep and venture is required for these advantages in examination with a great deal of intensity framework parts. A strong purpose behind why capacitors are most welcome in many power frameworks is planning costs itself.

Capacitors, in three stage control framework, are for the most part introduced inside non-channel metal box a separating which is called capacitor bank. The capacitor banks are accessible in two modes either exchanged or settled. Utilizing intertwined switches, settled banks are associated for all time to the essential conductors. With the utilization of computerized switches ,the exchanged banks are associate with the essential framework. This enables them to be put on line and taken disconnected as and when required. Capacitors in circulation control framework are generally associated in parallel (shunt) instead of arrangement association. As and where required the shunt control capacitor will be utilized to gives driving capacitive kVARs to an electrical framework.

In light of conventional want control factor, evaluated voltage, and so forth with the genuine framework, it is recommended that capacitor bank ought to be put at some place with settled attractive separation. Utilizing ungrounded Y-association is another strategy. This is helpful to put off symphonious creation. Be that as it may, with the assistance of investigation of capacitor changes is necessary to capacitor bank cut off and to quit exchanging counter assault. Interfacing in delta development for little capacitor bank, likewise have the equal impact; yet it should ensure that appropriate release work be obliged to be introduced. The release capacity can be performed by resistors associated between the three-stage delta-associated capacitor line to line. In this sort of plans, the exchanging impact issue should in any case be advised.

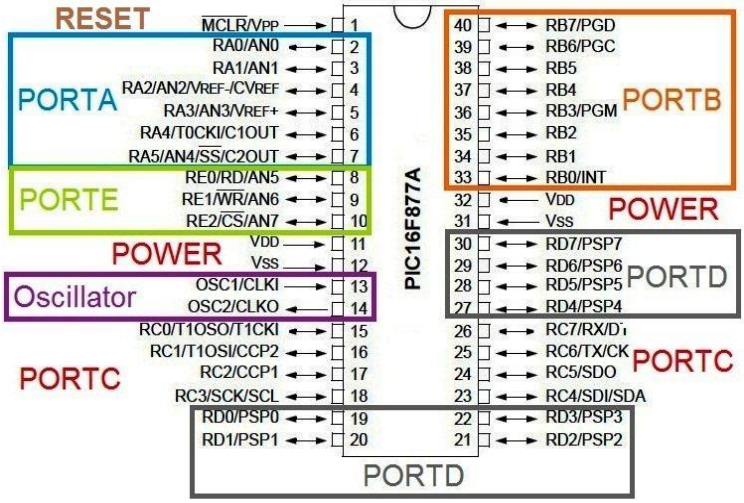

Fig 1.3 Pin diagram of 16f177A

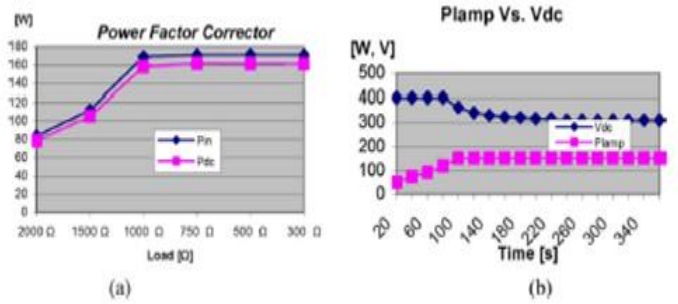

Fig 1.4
(a) PFC input and output power
(b) P.V_{dc} during start-up and warm up time

Results and Discussions

Three major parts have been utilized in the framework structure, execution and testing. These three sections are test on zero intersection indicator, test on a three-stage framework and test on single stage framework. Singular testing was done in two unique areas, since the power factor (PF) testing has slight contrasts between both three stage and single stage of the sine waveform so that to avoid PIC take in intemperate negative voltage; in the meantime, it itself depleted some voltage consequently channel waveform was marginally lower.

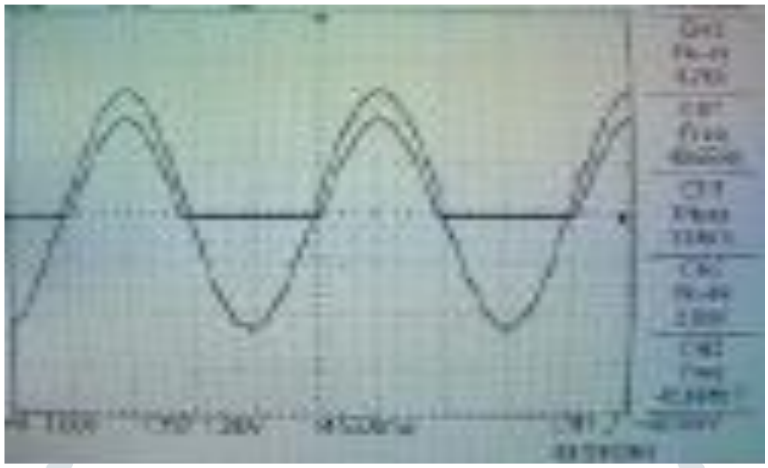

Fig 1.5 Input voltage after diode (clipped)

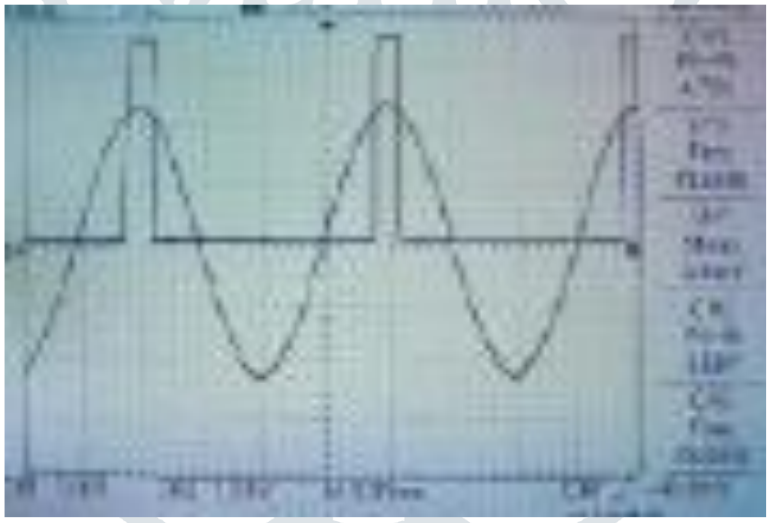

Fig 1.6 Output Voltage with Vref =3.74

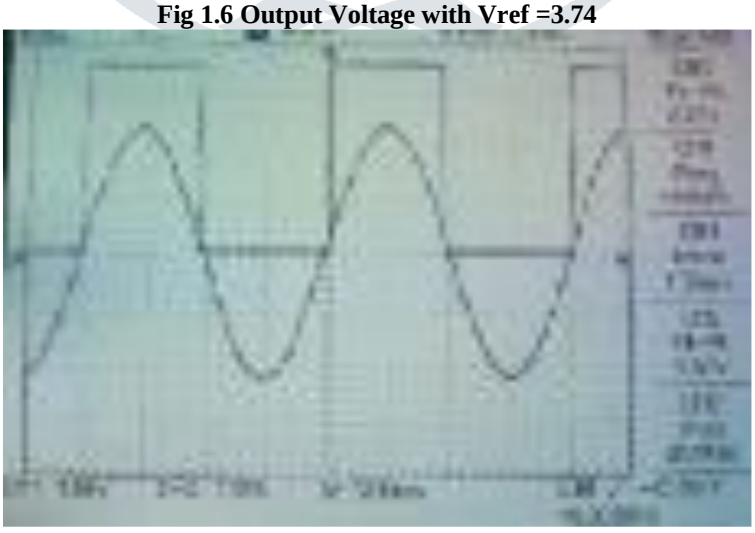

Fig 1.7 Output Voltage with Vref =0.524V

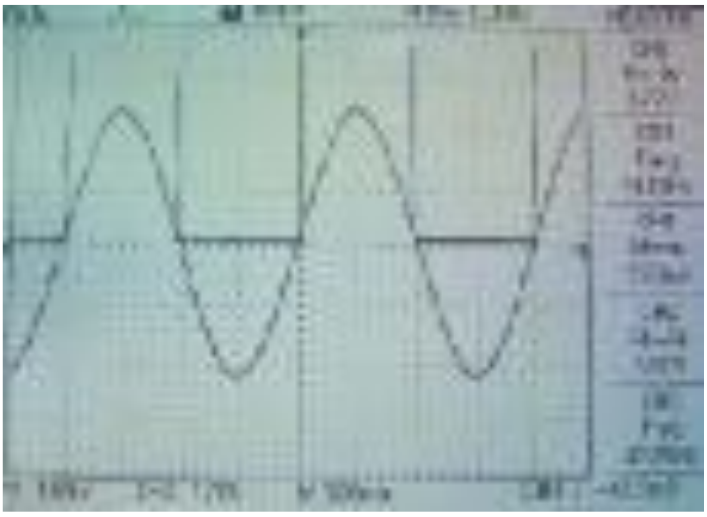

Fig1.1 Output Voltage after apply capture mode

Ensure a shunt resistor of any esteem must be associated after the diode and connection to ground, this will avoid symphonious shows up. Before acquired the yield waveform in Fig 1.7, it ought to know that stick 6, which is RA4 is an open deplete yield that pull down yield flag, hence a draw up resistor is required by interfacing it to VDD then capable turn out with wanted yield. The DC control supply was associated with port (2) and provided a reference voltage as limit voltage, which is lower than 5V. The reference voltage provided into port (2), were 3.74V consequently the data transmission of the square wave rising heartbeat train was little. All together to locate exact zero-intersection point, the edge voltage were lessened until achieving roughly 0.524 V before invalid, the rising edges and falling edges were superbly drop on each zero, this are unmistakably shown in Fig 1.7. Yield waveform in Fig 1.1 was really sufficiently adequate to apply into the program coding to run whatever is left of the analyses.

The testing procedure does not run test on power converter based frameworks or synchronous engine. Because of required tremendous measure of cost, one may need to additionally improve the framework to such element. Monetarily it is a basic issue upon further upgrade. Other than frameworks contains genuine symphonious current or sick non-sinusoidal current.

Variable Voltage Variable Frequency Sinusoidal Power Source using SPWM

An important issue in gadgets building space is the proficient utilization of accessible power for different kinds of interest. As per explicit requests of enterprises, the industry has concentrated on advancement of committed kinds of intensity sources. Age of air conditioning sources having variable greatness, variable recurrence, diverse kinds of waveform shapes and distinctive PWM methods, are the different means by which such necessities are determined. There might be structure and improvement of single stage or three stage control sources or distinctive controlling methodology, contingent upon the prerequisite. Portrayal of execution of air conditioning sources can be explicitly performed with the utilization of such power sources. As the new age gear introduced for expanding efficiency all the time end up being the significant wellsprings of making extra power quality issues, the nature of electrical power created is steadily turning into a matter of real concern. The plan of high caliber, variable voltage variable frequency (VVVF) control source with an extensive variety of unadulterated sine waveforms, with an extensive variety of recurrence has been the general thought.

There has been a necessity these days for the nature of electrical power and devoted sorts of intensity sources as indicated by particular. Thus, the created framework depends on the prerequisites of the application. The variable voltage and variable frequency power source has been given. The yield in this framework can change either voltage or recurrence. Another terminology for this framework is the DC-interface. With the end goal of control, this framework utilizes PIC controllers. Fig 1.9 demonstrates the structure of proposed framework.

To plan variable voltage and variable recurrence control source requiring little to no effort, steadier and more dependable framework at wanted reaches is the principle point of this framework. Sinusoidal Pulse width modulation technique (SPWM) has been utilized as a PWM procedure alongside 16f177a PIC controller and 16×2 LCD show with the end goal of showcase. There has been an expansion in the power factor.

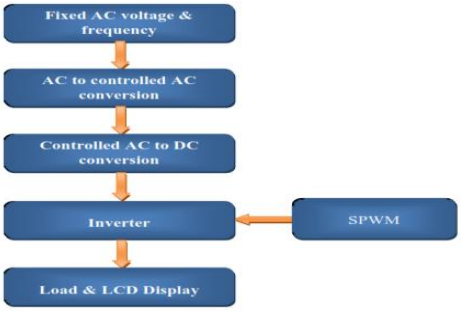

Fig 1.9 Structure of Proposed System

Working

The improvement of a microcontroller-based single stage VVVF sinusoidal power source utilizing MOSFET H-connect inverter is portrayed in the square outline. An epic idea of producing appropriate PWM signals, called sinusoidal heartbeat width regulation strategy is utilized. In this plan, same and fix adequacy beats are made with various obligation cycles for every period. To acquire inverter yield, the widths of these heartbeats are appropriately adjusted. For sinusoidal flag age inside the power source itself, the plan is structured with look-up table (LUT) installed inside the power source itself. There are a few points of interest offered by this plan. These incorporate enhanced solidness and superior power over the produced sinusoidal flag. Two microcontrollers have been utilized in this framework. One of the two microcontrollers is utilized to create the proposed variable voltage and the other one is utilized for controlling the recurrence. LCD is utilized as yield gadget for the created power source.

The voltage controller is connected with the fixed voltage, fixed frequency (FVFF) air conditioning voltage from the mains. To keep up the voltage at a coveted dimension, the controller is associated with a criticism compensator. To deliver a dc voltage, this voltage is then corrected utilizing a full wave connect rectifier. To change over this dc voltage into air conditioning once more, a MOSFET H-connect inverter, involving four MOSFETS, has been utilized. Since it is simpler to practice command over dc than air conditioning, this transformation of air conditioning to dc and after that dc to air conditioning again is required. The MOSFET needs the driver circuit to driving purpose. The recurrence and voltage that is produced utilizing the proposed plan will be shown on LCD display.

PIC 16F177A

The 40 pin IC, IC, PIC 16F177A having elite, low power, fast RISC controller is utilized in the proposed framework. The controller has inbuilt 10-bit ADC having 1-channel. The speed on which the PIC controller will work is DC - 20 MHz clock info and guidance process duration is 200 ns. The FLASH memory of 32K x 14 words has been given as program memory. The information memory is 1536 x 1 bytes, gave as RAM. There are two Capture, Compare, PWM modules accessible. The interfere with ability of up to 11 sources is accessible. 33 input/yield pins are given and scope of working voltage is somewhere in the range of 2.0V and 5.5V. The said PIC controllers can be utilized for controlling the stage point of triac, age of SPWM and show reason.

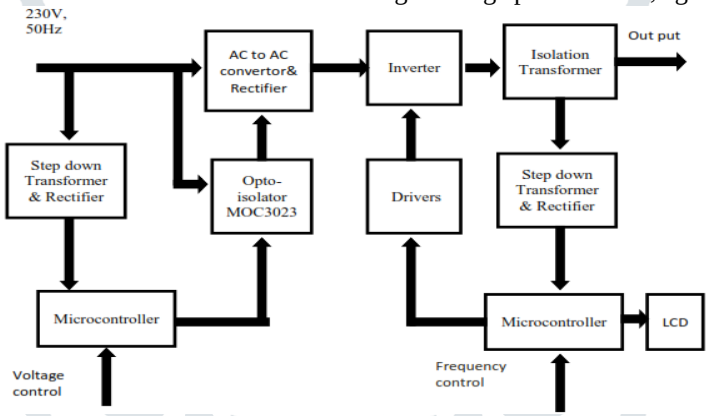

Fig 1.10 Block diagram of VVVF system

Power circuit

The different principle constituent parts of intensity circuit are circuits for zero intersection, triac terminating, full wave rectifier, channel and inverter. Toward the finish of this report, the schematic of the power circuit has been attached. The voltage regulator is at first connected with the settled voltage and settled recurrence air conditioning power at 230 V, 50 Hz from mains. Utilizing basic obstruction potentiometer, the yield voltage can be controlled at any coveted dimension. The full wave connect rectifier is connected with the yield from the controller. Air conditioning to DC transformation has been performed utilizing rectifier. The LC channel is utilized after rectifier. To restrain the current amid switching, the inductor is utilized and to get a smooth, swell free, dc yield, a high esteem capacitor is associated.

The H-connect inverters are connected with the yield from the rectifier. The four n-channel upgrade type MOSFETs establish the H-connect inverters. By utilizing the driver circuit, the exchanging of these MOSFETs is controlled. The door and wellspring of each MOSFET gets beat from the driver circuit. A specific MOSFET instantly turns ON when the driver circuit sends heartbeat to it and the MOSFET is killed when the beat is evacuated. At a specific exchanging instant, this succession of exchanging is planned so that it works on sets of MOSFETs. For instance, at a specific moment, the MOSFET1 and MOSFET4 are in ON condition and the other combine MOSFET2 and MOSFET3 is in OFF condition. Simply the invert occurs, in the following exchanging moment. This shows when MOSFET2 and MOSFET3 are turned ON then MOSFET1 and MOSFET4 are killed. With the end goal of assurance, R-C snubber circuit is utilized for each MOSFET. The confinement transformer has been utilized at yield side.

The yield waveform is smoothened with the guide of confinement channel. An unadulterated sine wave has been gotten over this channel. Utilizing venture down transformer, the yield voltage is ventured down. Utilizing the controller this voltage is detected and with the assistance of LCD as a yield gadget, the yield voltage and recurrence is shown.

Sinusoidal Pulse Width Modulation (SPWM)

Sinusoidal heartbeat width balance control is one of the imperative methods. In this strategy, by contrasting a triangular reference voltage of recurrence and plentifulness, with a bearer half sinusoidal voltage of variable abundance Ac and recurrence 2fs, the beat widths are produced. There is an in stage connection between sinusoidal voltage and the information stage voltage and sinusoidal voltage has double the info supply recurrence fs. By changing the abundance or the regulation list from 1 to 0, the yield voltage and the widths of the beats and are shifted. The estimation of tweak list, M is figured as the proportion Ac/Ar. There is a variable width of heartbeats that are gotten utilizing this plan. At the focal point of the transporter flag, the widths of the beats are littler, while the beat widths increment as one goes to end and the beginning of the flag. The an assortment of waveforms, including the information current and the flows through thyristors and load current thought to be nonstop have been appeared in Fig 1.11. In the prior case (various PWM control), it might be noticed that, the beat widths are uniform (meet). The dislodging factor, in this sort of control, is solidarity, and there is an enhancement in power factor. There is a decrease or disposal in the lower arrange music. For instance, four heartbeats for every half cycle, the most reduced request symphonious is the fifth, etc. To take one such precedent, diverse adjustments have been proposed, as the beat width one little in the inside as appeared in Fig. 1.11, the transporter flag is altered to mind of this. Up to some point from the begin and end of the cycle, the triangular waveforms are kept same, and afterward the width of heartbeat might be made reliable. The symphonious segments of the voltage waveforms are additionally lessen or disposed of, for various PWM techniques.

The assignment of making of the required yield has been accomplished by looking at the required reference waveform i.e. adjusting signal with a lifted recurrence triangular wave, as displayed schematically in Fig1.12. This is the most clear execution. In view of the choice of whether the flag voltage is more prominent than or not exactly the bearer waveform and additionally either the positive or negative dc transport voltage is connected at the yield. The normal voltage connected to the heap is relative to the sufficiency of the flag which is expected consistent amid the time of a triangle wave. Means the normal voltage connected to the heap will change as indicated by the adequacy of flag. This is pertinent over the time of one triangle wave. The subsequent slashed square waveform contains a copy or copy of the coveted waveform in its base recurrence parts, with the large recurrence segments being at frequencies close to the transporter recurrence. The DC transport voltage and the air conditioner rams voltage esteem waveform are as yet observed to be equivalent and consequently the THD did not influenced by the said PWM process. In view of inductances in the air conditioner framework, the symphonious segments are simply moved into the substantial recurrence go and consequently separated. The m=Am/Ac is known as the balance list,

Where

Am =the balancing signal is a sinusoid of sufficiency and

Ac =the sufficiency of the triangular transporter is.

The sufficiency of the connected yield voltage is controlled by controlling the tweak list. The high recurrence parts isn't stream legitimately in the air conditioner organize (or load)at the nearness of the inductive components, with an adequately huge transporter recurrence. As indicated by Fig 1.13 drawn for

$t = T/3 = L/R$,

$fc/fm = 21$;

where T = period of fundamental.

A bigger number of exchanging per cycle and consequently in an expanded power misfortune are not an aftereffect of higher transporter recurrence. For power frameworks applications ordinarily exchanging frequencies in the 2-15 kHz run are viewed as satisfactory. In three-stage frameworks, it is fitting to utilizes that all three waveforms are symmetrical.

$$\frac{f_c}{f_m} = 3k\,,(k \epsilon N) \qquad (1.1)$$

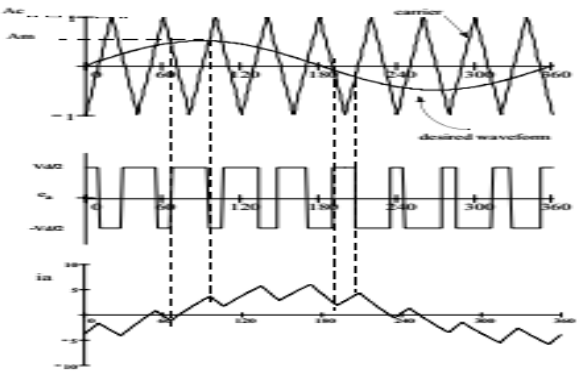

Fig 1.11 Principle of Pulse Width Modulation

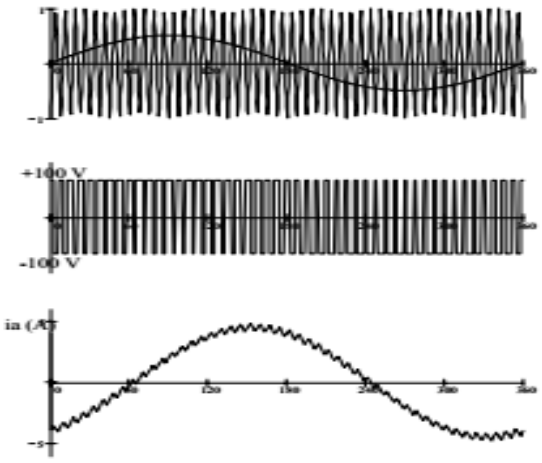

Fig1.12 SPWM with fc/fm = 41, L/R = T/3

As shown in Fig1.12, there are times of the triangle wave in which the flag and the transporter are not converging to one another. In light of a legitimate concern for acquiring a bigger measure of air conditioning voltage and a specific measure of this "over regulation" is regularly permitted, despite the fact that the ghastly substance of the voltage is rendered fairly poorer. The waveform is hostile to symmetric over a 360 degree cycle with an odd proportion for fc/fm. There are sounds of even request, with a significantly number, however specifically additionally a little dc part. especially for little proportions of fc/fm, for single stage inverters, in this manner, a significantly number isn't prescribed.

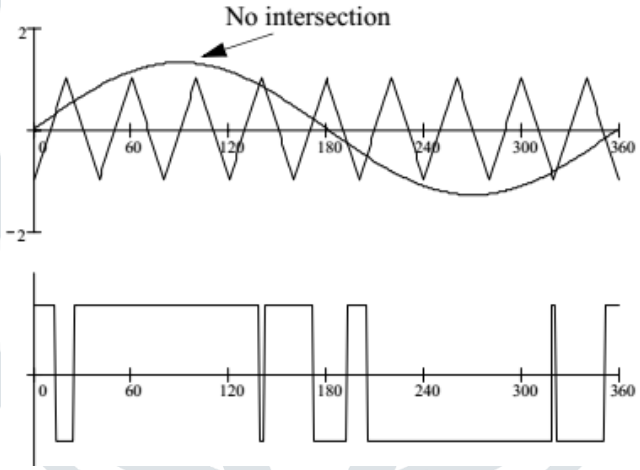

Fig 1.13 Over-modulation: m= 1.3

Control circuit and display circuit

In this system two PIC 16F177A controllers are used; one for variable voltage reason and second for variable recurrence and showing purpose.PIC 16F177A is the 40 stick IC. It requires gem, +5V control supply and ground. For variable voltage and recurrence reason variable resistive pot is associated with controller. Pot gives simple voltage to the controller thus ADC is utilized which changes over simple voltage in to advanced. The voltage will be control by the controlling trial's terminating point.

The PWM is the core of inverter. The second controller is utilized for the SPWM reason. For the unadulterated sine wave reason 121 positive and 121 negative advances are given. In SPWM, the sine wave is contrasted and triangular transporter wave. Thus, the look into table is produced for PWM reason utilizing the equation sin (θ)* FF. For the variable recurrence reason the qualities are determined. For instance, in the event that the 40Hz recurrence is required,

Time =1/40= 25msec;

Time= time/4= 0.156msec;

TMR0 = 256 – ((crystal frequency * time) / (4* presale))

=256 –((8MHz* 0.156 msec) /4*8)

=256- 39

=217

And this qualities additionally store in LUT.

The yield voltage is detected and shows the voltage and recurrence on LCD. 16 stick LCD is utilized out of that 1 information pines are utilized and three compose/read, empower and select stick are accessible.

Results and Discussion

This section clarifies the outcomes acquired from proposed framework. Results acquired with reenactment and experimentation is presented. The estimation of DC voltage crosswise over capacitor and AC voltages at yield side is performed. The different waveforms acquired amid the reproduction and exploratory works are additionally presented. The trial set up of the framework is appeared in Fig 1.14.

Fig 1.14 Hardware view

At the test purpose of the framework, the waveforms are taken. The accompanying figures demonstrate the aftereffects of the framework.

Utilizing venture down focus tab transformer, at first 230V AC is ventured down. The AC voltage is then redressed. The principal wave in Fig 1.15 is the corrected wave. The zero intersection beats are produced utilizing zero intersection circuit. Two zero intersection beats are 10 msecond separated. The zero intersection beats are appeared in the second beat of Fig 1.15.

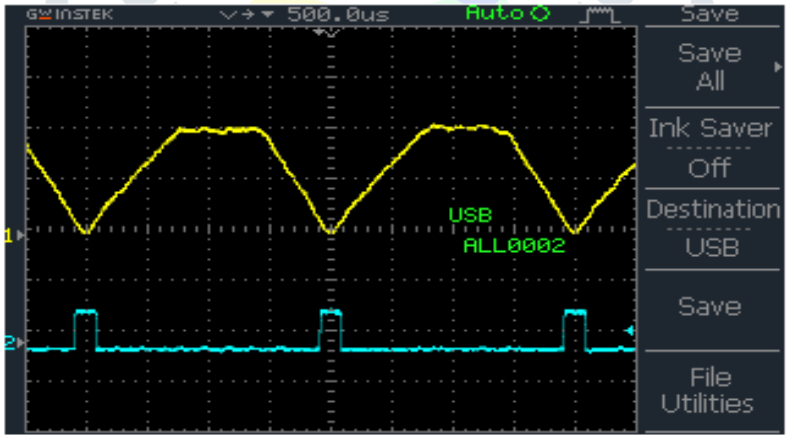

Fig 1.15 Rectified pulse and zero crossing pulse

The controller considers this zero intersection beats as an outside interfere. As indicated by pot position the controller produces the triac terminating beats concerning zero intersection beats. In Fig 1.16 first heartbeats are the zero intersection and second heartbeats are the triac terminating beat. These heartbeats are move regarding zero intersection.

This control beats are given to the opto-isolator to triac. In Fig 1.16 the AC flag is changed over in to control AC utilizing this control beat. In this framework this AC is changed over in to control AC as per pot position.

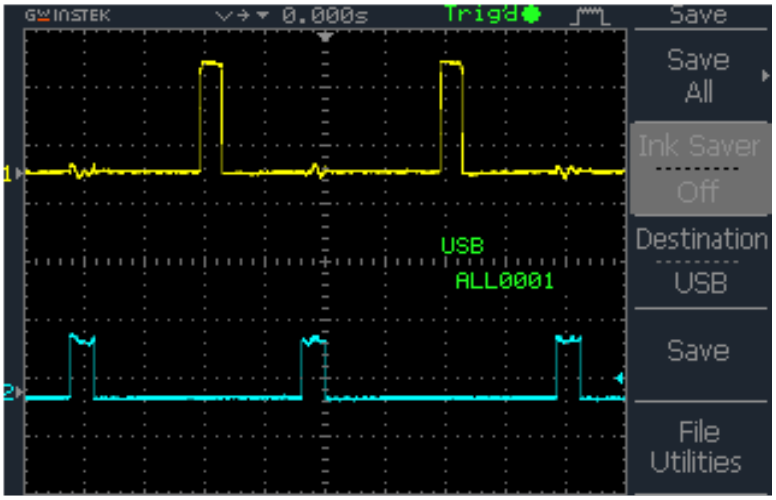

Fig 1.16 Zero crossing pulse and firing pulse of triac

Fig 1.17 Controlled AC signal and firing pulse

The second controller is utilized to create SPWM and showing reason. In Fig 1.11 demonstrates the SPWM beats at CCP1 and CCP2. At the point when CCP1 beats are available that time CCP2 has no heartbeats and the other way around.

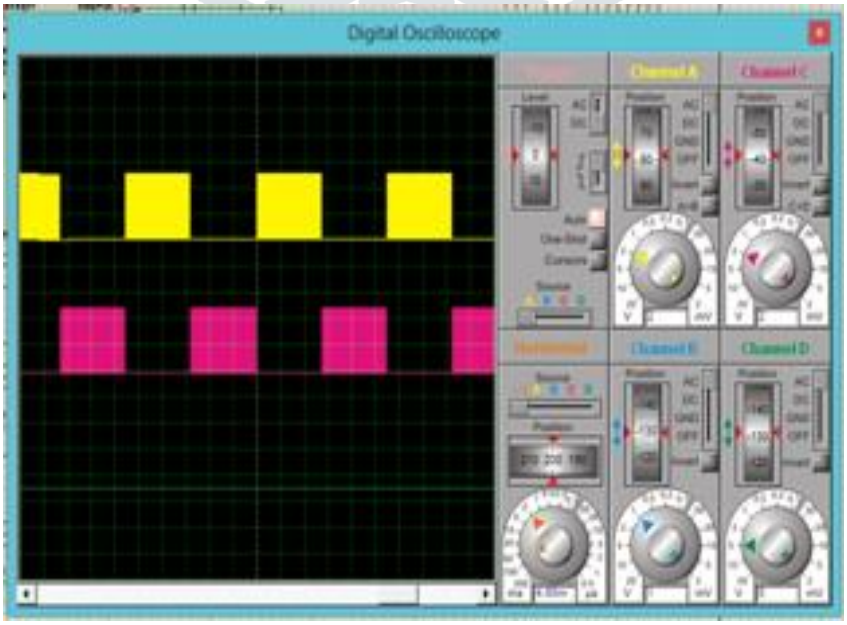

Fig 1.11 pulses at CCP1 and CCP2

The total half cycle is divided in to 10 steps. At high pick of sine wave width of SPWM is maximum as shown in Fig1.19.

Fig 1.19 Pulses at CCP2

In Fig 1.20 we see the SPWM pulses at CCP1 and CCP2.

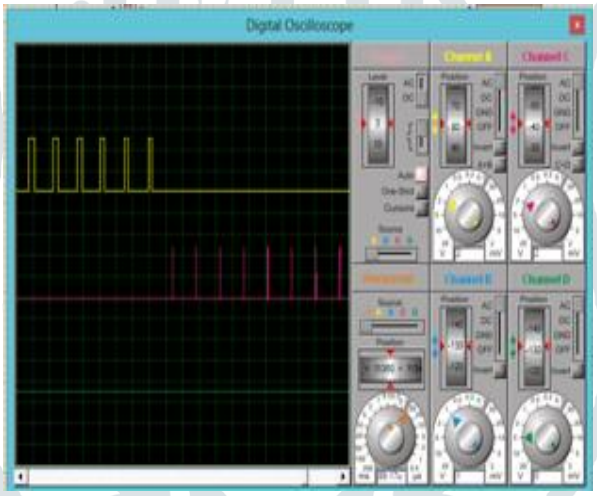

Fig 1.20Pulses at zero level

The SPWM beats are given to inverter. Utilizing first controller, the yield voltage of the framework can change. At the point when stack implies globule is associated with yield side. At the point when triac is completely fire that time force of knob is greatest. The yield AC voltage is 61V AC.

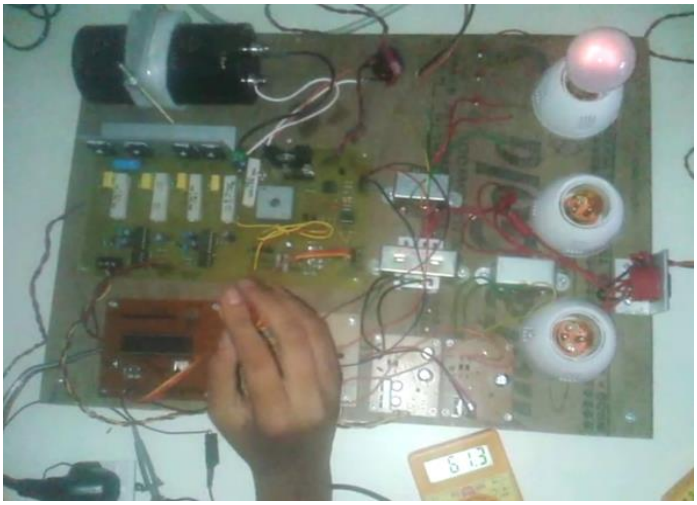

Fig 1.21 Output with load at maximum firing

As indicated by pot position voltage is changed and force of light likewise changes. So the yield voltage is change from 61 V to 30V. In Fig 1.22, Fig 1.23, Fig 1.24 and Fig 1.25 the yield voltages are 59V, 57V, 41V and 31 V. so the power of globule likewise changes.

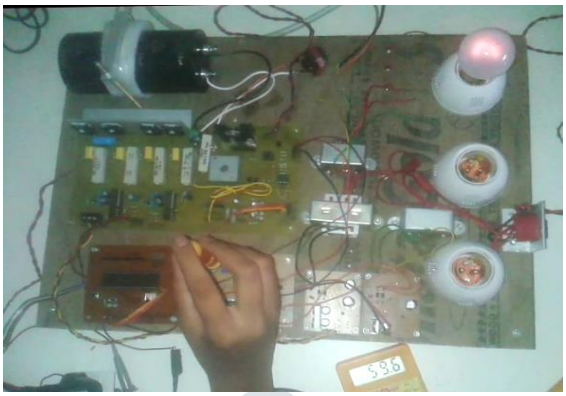

Fig 1.22 Output with load at changing firing angle

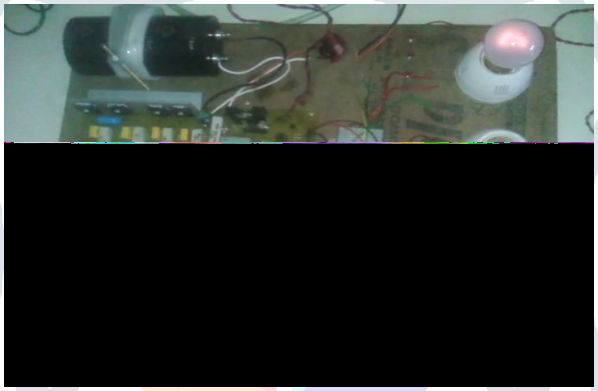

Fig 1.23 Output with load at changing firing angle

Fig 1.24 Output with load at changing firing angle

Fig 1.25 Output with load at changing firing angle

Fig 1.26 shows the sign wave at output. At output side filter is designed. So this waveforms present across filter.

Fig 1.26 Output sine wave at 40 Hz

In Fig 1.27 frequency of sine wave is 40 Hz. Similarly in Fig 1.21, Fig 1.29, Fig1.30 and Fig 1.31, frequency is 44Hz, 51Hz, 60Hz, and 70Hz.

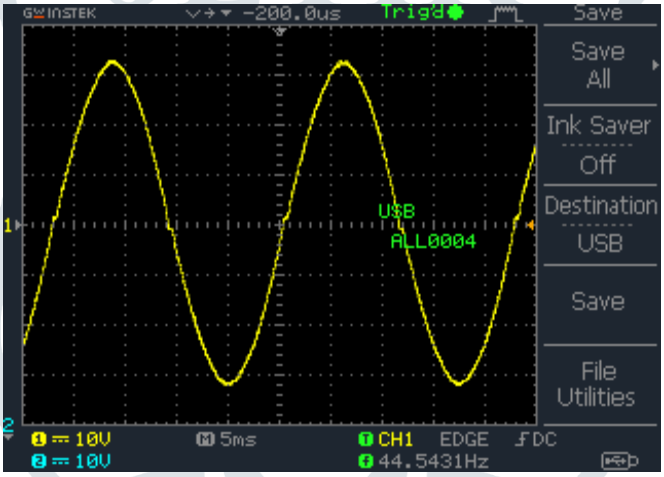

Fig 1.27 Output sine wave at 44.5 Hz

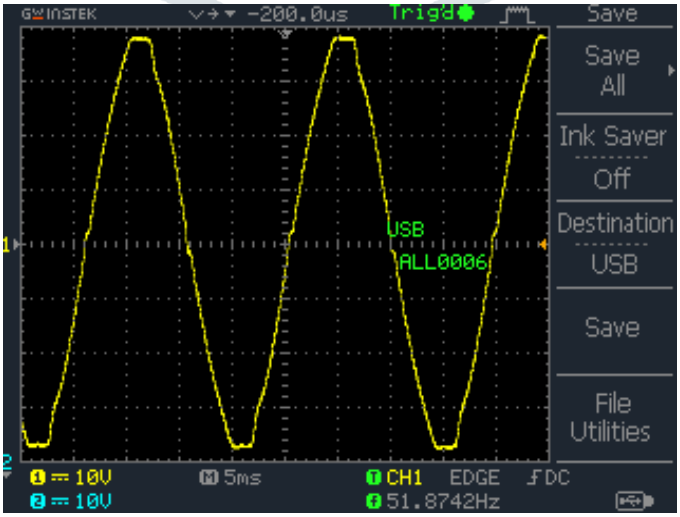

Fig 1.21 Output sine wave at 51Hz

Fig 1.29 Output sine wave at 60Hz

Fig 1.30 Output sine wave at 70Hz

The output voltage and frequency of the system is displayed on LCD. The display figure is shown in Fig 1.31.

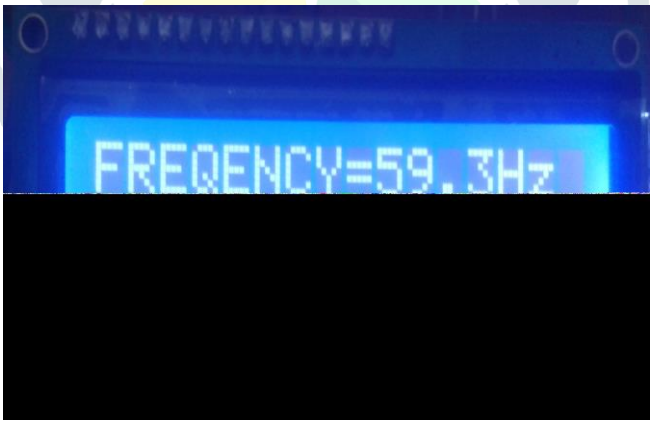

Fig 1.31 LCD display

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