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A microcomputer using Controller for Generation PWM

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Abstract*—*Design and construction of microcomputer for inverter controlling, this inverter is designed by using power electronics switches type MOSFET. The MOSFET's are controlled by using pulses depending on sampled sinusoidal Pulse Width Modulation (SPWM) technique with frequency ratio changing. Constant voltage to frequency (V/F) ratio is maintained through the program leading to constant flux speed range. The range of inverter output frequency is (0→50 Hz). This inverter output control the 3-ph induction motor speed.

I. INTRODUCTION

When the supply voltage is constant and the frequency is varied that the torque speed curve is efficient wide range speed control of the induction motor is possible when a variable frequency ac supply is available.

The inverter provides a controllable ac power supply over a wide range of frequency.

The motor flux will increase leading to excessive core losses and high magnetizing current [1].

Various techniques for achieving voltage control frequency control and reduction of the harmonic effect and torque pulsation are investigated in this project.

II. POWER CIRCUIT AND GATING FREQUENCY

Pulse Width Modulation (PWM) is the technique of using switching devices to produces the effect of a continuously varying analog signal this PWM conversion generally has very high electrical efficiency in controlling a three phase synchronous motor or a three phase induction motor it is desirable to create three perfectly sinusoidal current waveforms in the motor winding, with relative phase displacement of 120degree.

The production of sine wave power via a linear amplifier system would have low frequency, at fast electronic switching devices used then the efficiency can be greater than 95% depending on the characteristics of the semiconductor power switch [2].

The half bridge switching shown in figure1, the switches can be any suitable switching semiconductor.

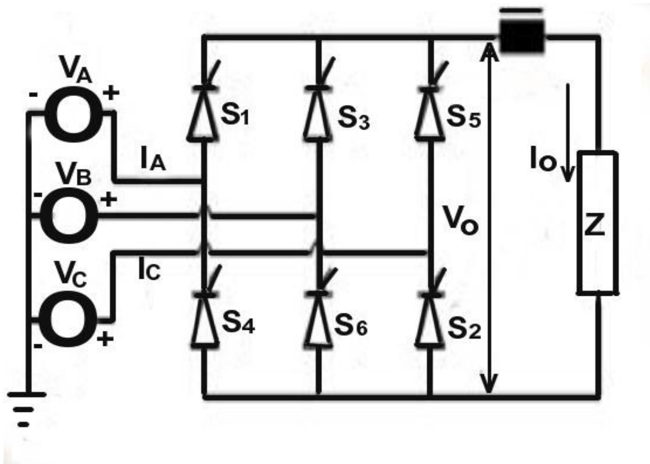

Fig. 1 Three phase controlled power circuit

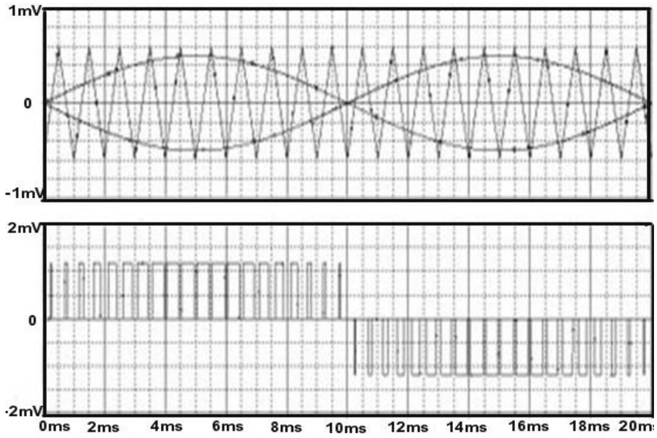

Fig. 2 Intersection waveforms and generated PWM

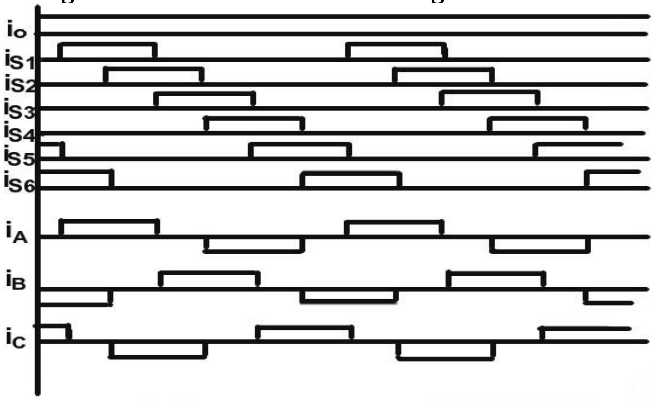

Fig. 3 Three phase output current when the output is filtered

If these switches are turned on alternately for equal times, then the voltage waveform across the load is shown in fig. 2.

The mean value of this waveform, averaged over one switching cycle is 0.

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This square wave with a constant 50% duty ratio is known as the "carrier frequency" the waveform in figure 3 shows the effect of a slow variation or modulation of the duty cycle ratio, the mean voltage varies with the duty ratio [3].

The waveform of the resultant load current depends on the impedance of the load Z, because the impedance mainly is resistive then the waveform of the current will closely follow that the modulated square wave.

If Z is largely inductive as with a motor winding or a filter choke, then the switching square wave will be integrated by the inductor. The result is a load current waveform that depends on the modulation of the duty ratio.

The apparent power from the three phase source is;

$$S = \sqrt{3}V_{L-Lrms}I_{Srms} ---------------(1)$$

The average dc value of the output voltage is;

$$V_o = \frac{1}{\pi/3}\int_{\frac{\pi}{3}+\propto}^{\frac{2\pi}{3}+\propto} V_{mL-L}\sin(\omega t)\,d\omega t = \frac{3V_{mL-L}}{\pi}\cos\propto -(2)$$

Harmonic for the output voltage remain of order 6k, but the amplitudes are function of $\propto$.

$$V_{mL} = Peak\ to\ peak\ line\ voltage = \sqrt{2}V_{L-Lrms}$$

$$V_o(t) = V_o + \sum_{n=6,12,18,\dots}^{\infty} V_n\ Cos(n\omega_o t+\pi) ------(3)$$

$$V_n = \frac{6V_{mL-L}}{\pi(n^2-1)} ---------------------(4)$$

$n = 6,12,18, \dots\dots$

The harmonics in the output are order 6kw, k=1, 2, 3.When the load current is filtered by an inductances, output current is essentially dc.

Fourier representation of line current;

$$i_a(t) = \frac{2\sqrt{3}}{\pi}I_o\left(\cos\omega_o t - \frac{1}{5}\cos5\omega_o t + \frac{1}{7}\cos7\omega_o t - \frac{1}{11}\cos11\omega_o t + \frac{1}{13}\cos13\omega_o t - \dots,\right) -------------(5)$$

Harmonics of order 6k ±1, k=1, 2, 3…

Because these harmonic currents may present problems in the ac systems, filters are frequently necessary to prevent these harmonics from entering the ac system see figure 4, [4].

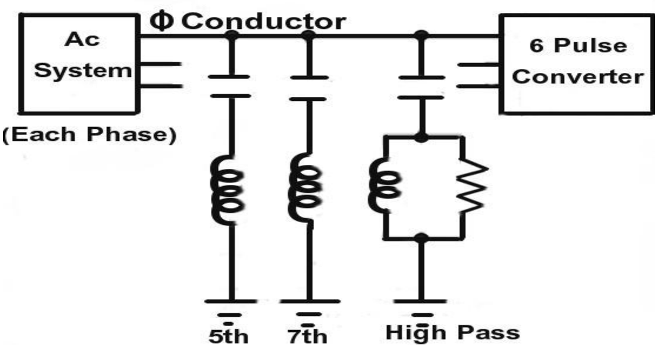


Fig.4 Filter for ac line harmonic

III. SIMULATION PROGRAM OF INVERTER OPERATION

The simulation program was designed and then programmed to explain the procedure of the PWM gating pulses, line to neutral output voltage generation and then calculates the magnitude of harmonics for different cases.

The PWM gating pulses are produced by comparing the instantaneous values for two equations is a sinusoidal waveform, being a reference, or modulated wave, and the second equation is unipolar triangular wave, used as a carrier wave.

The carrier wave is written by using Fourier series expression [5], the final equation for the unipolar carrier is:

$$f(t) = k/2 - 16k/\pi^2[\left(\frac{1}{4}\right)\cos\left(\frac{2\pi t}{L}\right) + \left(\frac{1}{36}\right)\cos\left(\frac{6\pi t}{L}\right) + \left(\frac{1}{100}\right)\cos\left(\frac{10\pi t}{L}\right) + \left(\frac{1}{196}\right)\cos\left(\frac{14\pi t}{L}\right) + \left(\frac{1}{324}\right)\cos\left(\frac{18\pi t}{L}\right) +, --] --- (6)$$

Where L= is the real number.

Each half cycle of the reference wave is divided by program to NS sample, where NS is an integer value; the resolution is equal (180/NS) degree, so the number of sample NS must be large for converted resolution. The resulting PWM gating pulses are then converted to the line to neutral output voltage. A magnitude of harmonics is carried out by using Fast Fourier Transform (FFT) method [6]. The equality of performance is determined by calculating the harmonic loss factor (HLF) for different cases.

IV. THE SIMULATION PROGRAM

The flow chart of simulation program as shown in figure 5 is started by entering information which are the number of samples NS, and carrier frequency FC Hz, modulation frequency FM Hz, and X-axis scale (harmonics selection) XS. The computation step frequency ratio and modulation index is done after an array formulation for the instantaneous value of carrier sample and modulated sample, real and imaginary parts of the sample and harmonics magnitude**.**

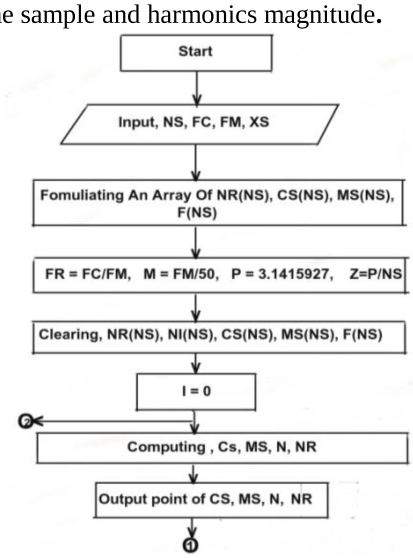
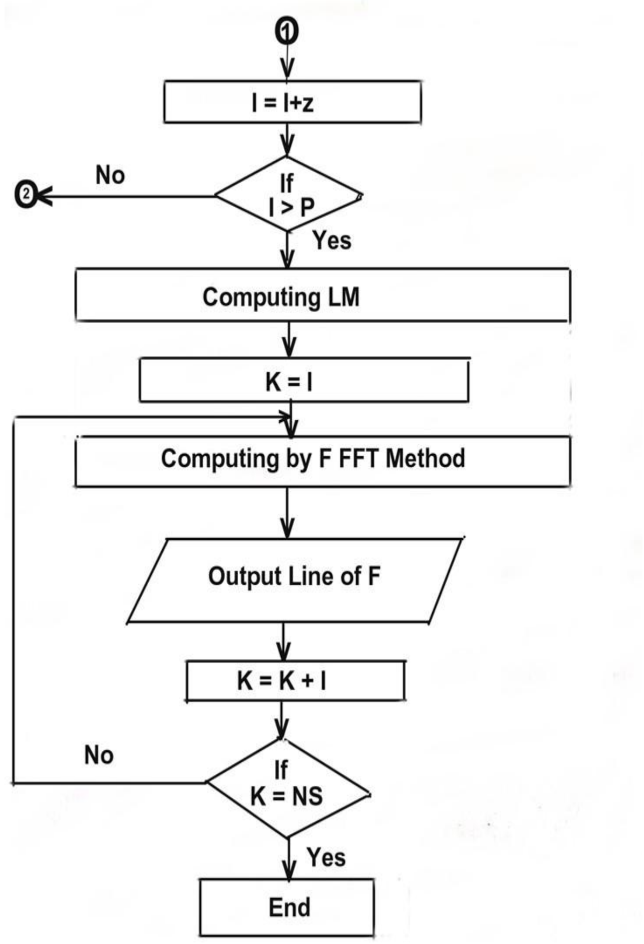


Fig. 5 Flow chart for simulation program



Where: NS: Number of sample, FC: Carrier frequency (Hz), FM: Modulated frequency (Hz), XS: Harmonic selection X-axis, NR: Real part of the sample, NI: Imaginary part of the sample, F : Harmonic magnitude, M : Modulation index, FR: Frequency ratio, Z: Phase shift between each 2 samples, CS : Instantaneous value of carrier wave, MS: Instantaneous value of modulation wave, LM: Logarithm parameter.

V. FREQUENCY RATIO AND MODULATION INDEX VARIATION ON HARMONIC

The effect was explained by the simulation program, the effect of frequency ratio variation on harmonic distribution for fixed modulation index is illustrated in figure 6,7 ,8 ,9,10 and the relationship between harmonic loss factor and frequency ratio is shown in figure 11. The advantage of a high frequency ratio is that the dominant harmonics are at high frequency with resulting current harmonics more radily filtered by the leakage inductance of the motor. Therefore for a better output, the value of frequency ratio is preferred to be higher [7]. The modulation index (M) has direct effects on the harmonic loss factor (HLF) because decreasing in modulation index causing an increase in the harmonic amplitude. This increase leads to increase the harmonic currents. The selection of a large frequency ratio can cancel the negative effect of modulation index (M) decreasing, so that the solution is to be use frequency ratio changing technique. The respective harmonic loss factor will be reduced when the carrier frequency is increasing of the values.

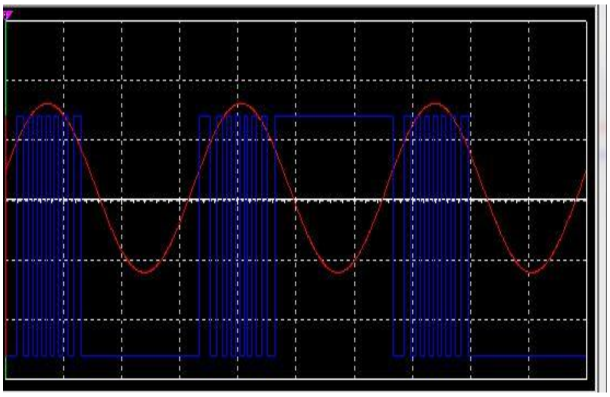


Fig. 6 Output voltage generation steps and harmonics distribution frequency variation
$(f_r = 8, M = 1, f_c = 300\ Hz)$.

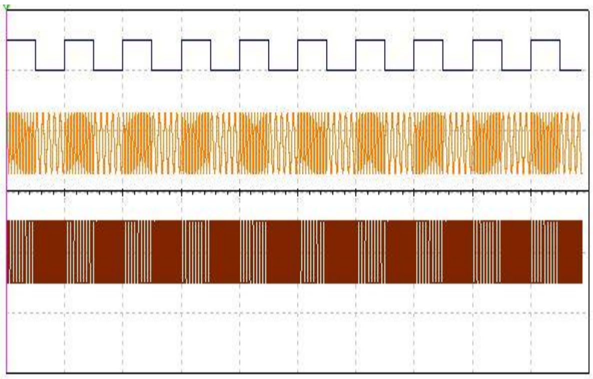


Fig.7 Output voltage generation steps and harmonics distribution frequency variation
$(f_r = 30, M = 1, f_c = 1500\ Hz)$.

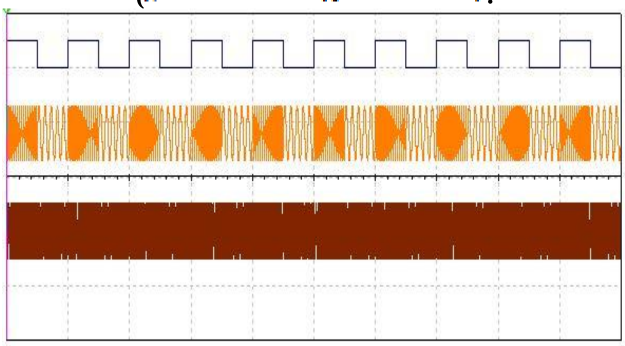


Fig.8 Output voltage generation steps and harmonics distribution frequency variation (f_r=20, M=1, f_c=1500 Hz).

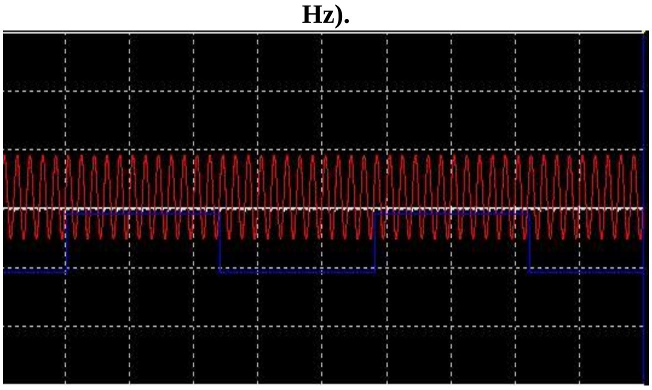


Fig.9 Output voltage generation steps and harmonics distribution frequency variation
$(f_r = 24, M = 1, f_c = 2000\ Hz)$.

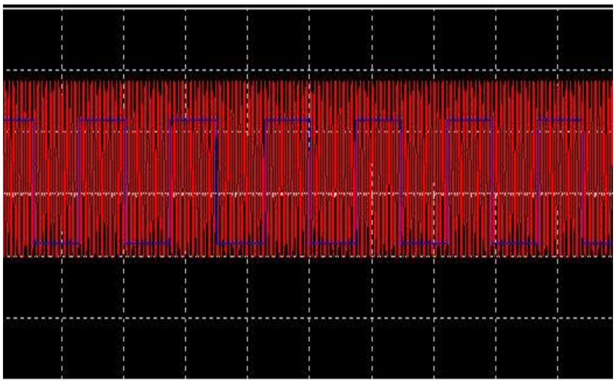


Fig.10 Output voltage generation steps and harmonics distribution frequency variation
($f_r = 24, M = 1, f_c = 2500Hz$).

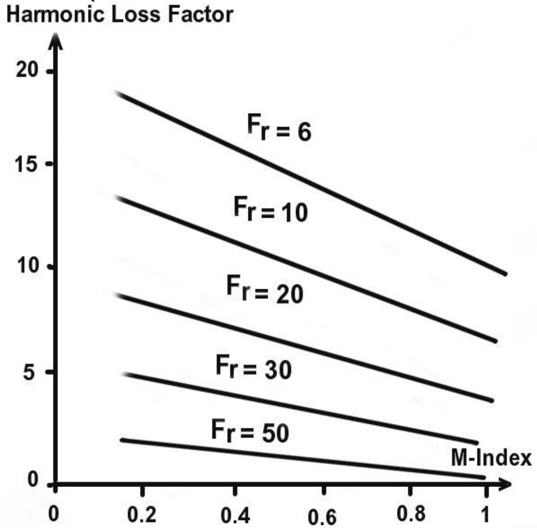


Fig. 11Relationship between harmonic loss factor and modulation index for different Frequency ratio.

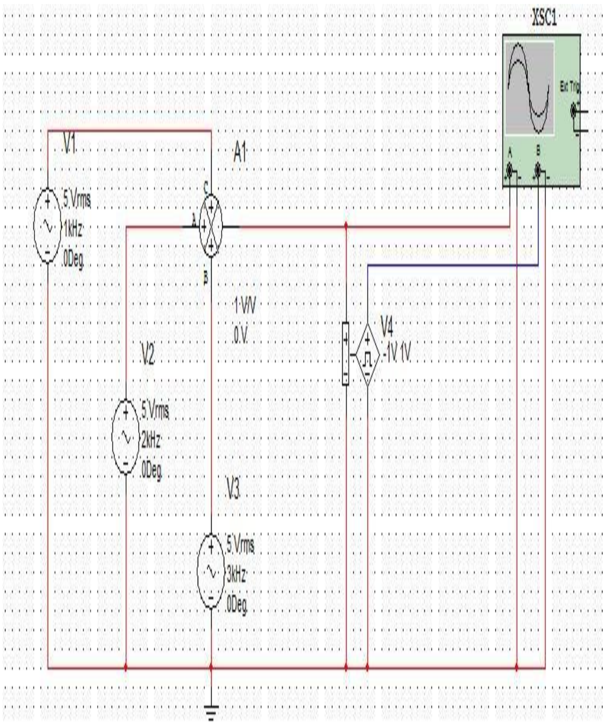


Fig 12 Multisim simulation to generate PWM and harmonic loss factor

VI. MICROCOMPUTER INTERFACE CIRCUIT

The interface circuit is connected with the microcomputer through the ROM cartridge slot. There are four programmable peripheral units (PPI) type 8255A used for input/output data to from the microcomputer through buffers. Buffers have high input impedance and low output impedance this means a low input current and a high output current. Since the output current of a standard TTL gate can be 10 times the input current. So the buffers are necessary for more stable interface circuits which consist of large number of integrated circuit chips.

The PPI is a programmable input output device [7, 8]. It has three ports each of which can be programmed as input or output port through a control word sent to the control register at the PPI 8255 A chips, show in figure 13.

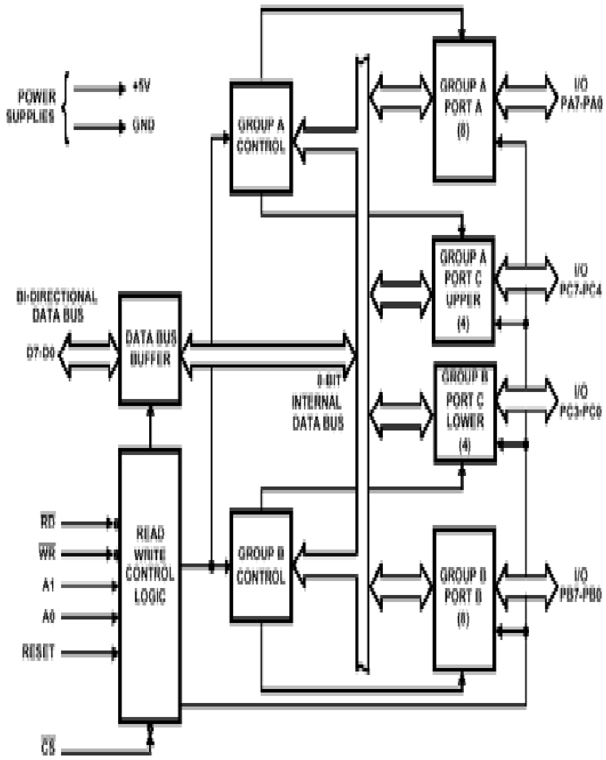


Fig. 13 Block diagram of PPI 8255A

The mode operation is mode zero which basic input /output mode for each one of the three ports. There are four PPIs the control of the chip selection is made by using 3/8 decoder which able to make selection on eight PPI chips, the address decoding for ports start from 80H up to 8FH, so the address of the first PPI ports are 80H, 81H, 82H, for A, B, and C ports respectively and the control word register address is 83H.The addresses of the 2nd PPI ports are 84H, 85H, 86H and the control word register address is 87H. The address of the 3rd PPI ports are 88H, 89H, 8AH and the control word register address is 8BH, and the addresses of the 4th PPI ports are 8CH, 8DH, 8EH and the control word register address is 8FH.

Port A (80H) is used as an input port to enter the digital value which is proportional to the dc link voltage and then the digital value of the required speed is entered. Ports B for 1st, 2nd, and PPI are used as output ports to deliver the digital form of three phases A, B, C sinewave respectively.

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Port C (82H) for the 1st PPI is programmed as input/output port (PC0-PC3) is output port and PC4- PC7) is input port. Port C is used to provide the start of conversion (SOC) and end of conversion (EOC) pulses for multichannel analog to digital converter (ADC) type 0808 with conversion time 5µs which deals with port A (80H). Port A (84H) of the 2nd PPI is used as an output port to deliver the channel selection for multichannel ADC that is connected with (80H) port. Port C (86H) of the 2nd PPI is used to deliver the desired stored voltage value for modulation index control. Port A (88H) is used as an input port to enter the starting operation command through PA0 (88H). Port C (8AH) is used as an output port to deliver setting ON signal to the two external controlled relays. The 1st relay is used to cancel the slow charging resistor through PC0 (8AH), and the 2nd relay is set ON after a short time delay 4 sec to connect the dc link voltage to the power inverter circuit after reaching the stable value of dc link voltage. Ports A, B, C for the 1st PPI are used as output ports to deliver 3- phase synchronized square waves. The pins reset IORQ, RD, and WR are used in interface circuit with desired address lines (A0-A7) to build up more accurate interface circuit.

VII. PULSE WIDTH MODULATION MODULATOR

The main operation of the modulator is to reduce the three phase PWM pulses for six driving circuits to drive the three phase MOSFET inverter. The modulator receives information in digital form 8 bit resolution from the output ports, that represent the sampled three phase sine waves through output ports, (81H), (85H), and (89H) for A, B and C phases respectively and also 3 phase square waves output ports (8CH), (8DH), (8EH). The other 8 bit information for modulation index control is received through the output port (86H) [1]. The modulator consists of three (DAC) and three analog voltage multipliers, three decoupling circuits and three PWM pulses generator one for each phase. An external triangular wave oscillator is included in the modulator.

VIII. EXPERIMENTAL RESULTS

The output PWM voltage generating procedure is obtained by PWM inverter drive system. The step of procedure is generation of 3 phase reference voltages VA, VB, and VC, which are storage data in microcomputer memory, as shown in figure 14.

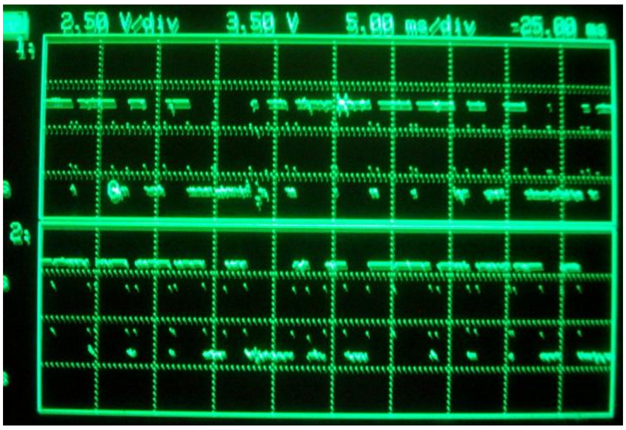

Fig.14 the measured line to line inverter output voltage waveform carrier frequency is 500Hz and voltage phase A, and B 5volt/div

IX. CONCLUSION

Design of these networks has significantly reduced the power switching losses of the MOSFETs. Clamping circuits are used to limit the over voltage across the MOSFETs and dissipates the energy stored in the central inductor of the switching aid network. A sampled sinusoidal PWM strategy used unipolar carrier triangular wave with a fixed carrier frequency and frequency ratio changing.

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