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Single Phase Induction Motor In Energy Efficient Mode

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Abstract— In this paper, a new model for single phase Induction motor is presented. A microcontroller based control scheme using pulse width modulation technique is developed .Single phase induction machine is most widely used in industry because of its simple construction, reliable operation, lightness and cheapness. In modern cities, motor drive systems can consume over half the electricity. Furthermore, those systems can consume over 75% of all the electricity in an industrial plant. Line-commutated AC controllers can be replaced by pulse width modulation (PWM) AC choppers, which have better overall performance and the above problems can be improved if these controllers are designed to operate in the chopping mode. In this case, the input voltage is chopped into segments and the output voltage level is decided by controlling the duty cycle of the chopper switching function. Using the proposed scheme, the voltage at the sta¬tor terminals is reduced during no load or small duty ratio load conditions, and electrical energy is saved.

Key words: Line-commutated AC controllers, duty cycle, etc

I. INTRODUCTION

There is a growing demand for power in the world. The generation is not able to meet the load demand. In addition, losses occur in transmission systems. Therefore, it is better to develop energy savers to conserve the energy that can minimize the load demand. Intelligence-controlled energy savers are not readily available in the market. In industrial complexes like drilling mills, most of the induction motors run at no load for most of time. These motors are always connected to the mains irrespective of the load conditions.

Sector	Share (in %)	Application
Industrial	70	Process and Material Handling Equipment
Commercial	38	Mainly HVAC
Agricultural	25	Agriculture Pumps and Fans
Residential	22	Refrigerators
Transport	60	Railways

Table 1

Due to the rated voltage at stator terminals, rated iron losses have to be supplied constantly to the motors. These losses mean a waste of some form of energy, which is in short supply. If it is possible to reduce the voltage at the stator terminals during no load or small duty ratio load conditions, then iron losses can be reduced and some electrical energy might be saved. Voltage controllers are increasingly applied as motor soft starters and sometimes as energy savers, reducing the flux level in the connected induction motor, in accordance with the load. Energy conservation is significant for induction motors .Various Energy Conservation techniques in induction motor are as follows

- Improving power quality Induction motor performance is notably affected by poor quality of input power. Many aspects in the term power quality such as voltage imbalance, frequency and harmonic distortion.
- Star Mode operation Motor operation at full load gives better efficiency as well as power factor in star mode as compared to the partial loaded motor in delta mode.

The performance characteristics of a symmetrical pulse width modulated single-phase AC chopper controller-fed single phase induction motor to achieve variable speed operations are evaluated. The controller employs a chopper circuit on the stator side of the motor. Speed control is achieved by varying the duty cycle of the switching function of the chopper as a suitable means for controlling the effective voltage applied to the motor terminals. The pulse width modulated AC chopper and phase angle controlled AC chopper fed induction motor systems are simulated and their performances are compared. It is proved that the pulse width modulated AC chopper system has lesser total harmonic distortion and better power factor. With reduced voltage, energy can be saved during the no load and partial load periods of a single phase induction motor drive.

II. CIRCUIT DESCRIPTION AND PRINCIPLE OF OPERATION

In this project we aim to create a single phase induction motor drive using pulse width modulated AC chopper and Microcontroller. The no load or partial load conditions of motor is sensed by Micro-controller, which in turn allows AC chopper to reduce the voltage across the stator of induction motor, Due which the speed of induction motor is reduced and over all energy is saved. The intention is to save energy of plant and improving efficiency of motor at no load or partial load using this drive.

A block diagrammatic representation of the microcontroller based AC chopper fed single phase induction motor is shown in Figure 1. A single phase supply of 230V AC. is given to the step down transformer circuit and the PWM AC Chopper. Further, the outputs of the step down transformer circuit is provided to the rectifier and Zero Crossing detector circuit (ZCD).Rectifier provides a D.C. supply voltage required by the microcontroller kit. Current is sensed using a circular shaped current transformer made from nickel iron alloy. Analog to digital converter i.e. ADC is used in the circuit to provide digital pulses to controller circuit obtained from the current sensor. This helps us to measure the current and display it on the screen.

A PWM AC Chopper which is fed from a single phase 230 V supply is used to connected to the induction motor and the microcontroller input is fed to it. The speed of the machine is sensed using photoelectric type digital pickup sensor. Speed sensor senses the speed and provides the data to the microcontroller in order to display speed on the screen. An LCD screen is provided to display all the results.

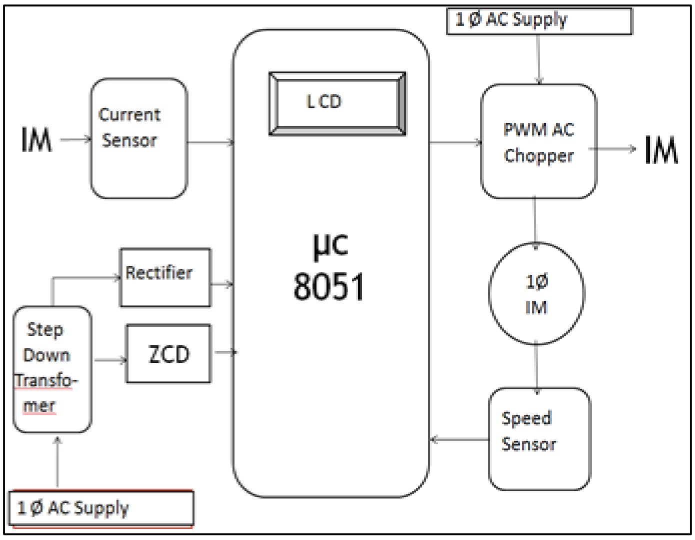

Fig. 1: Block Diagram

III. HARDWARE REQUIRED AND DETAILS

1) Single Phase induction Motor (0.3 HP,1500rpm)
2) Micro-Controller 8051 (8 bit, 64 kb flash memory)
3) Current sensor (ADC 3202, CT).
4) Power supply Circuit for µc.
5) Zero cross Detector (ZCD).
6) LCD Display (16x2).

IV. SINGLE PHASE INDUCTION MOTOR

A squirrel cage induction motor of rating 1HP, 230V, 6Amp,1420rpm,50Hz.CSCR type motor with mechanical loading used in the project.

Motor voltage and current and watts , speed and load balances W1 and W2

Rated Torque

T = (W1-W2)*A

A=Break drum constant =9.81

Output Power

P=2ΠNT

N=Motor speed in rpm

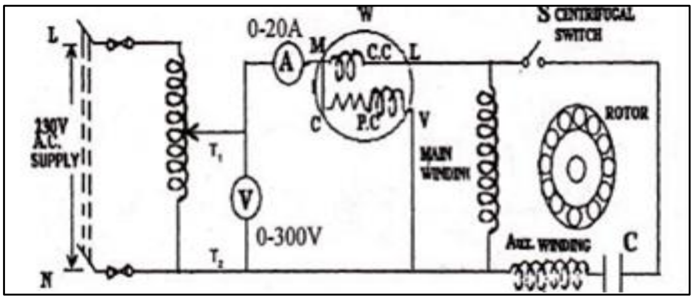

Fig. 2: Circuit diagram of load test on single phase induction motor

The machine is tested on no load on various voltages obtained with the help of autotransformer based on that different result are obtained which are as follows.

Sr No.	V	I	W
1	230	0.7	114
2	200	0.5	81
3	130	0.2	48

Table 2

CALCULATIONS
Power consumption
P = V I cosφ t
P = 230 *0.7*0.875*24
= 3.381 KWh
Similarly for different voltages from autotransformer we get different power ratings .
P = 2.1KWh
P = 0.546 KWh

V. MICROCONTROLLER 8051 OPERATION

The P89V51RD2 is an 80C51 microcontroller with 64 KB Flash and 1024 bytes of data RAM. A key feature of the P89V51RD2 is its X2 mode option. The capability to field/update the application firmware makes a wide range of applications possible. The P89V51RD2 is also In-Application Programmable (IAP), allowing the Flash program memory to be reconfigured even while the applic80C51 Central Processing Unit,5 V Operating voltage from 0 to 40 MHz,32 Programmable I/O Lines,64 kB of on-chip Flash program memory with In-System Programming and In-Application Programming ,Three 16-bit timers/counters ,Eight interrupt sources with four priority levels.

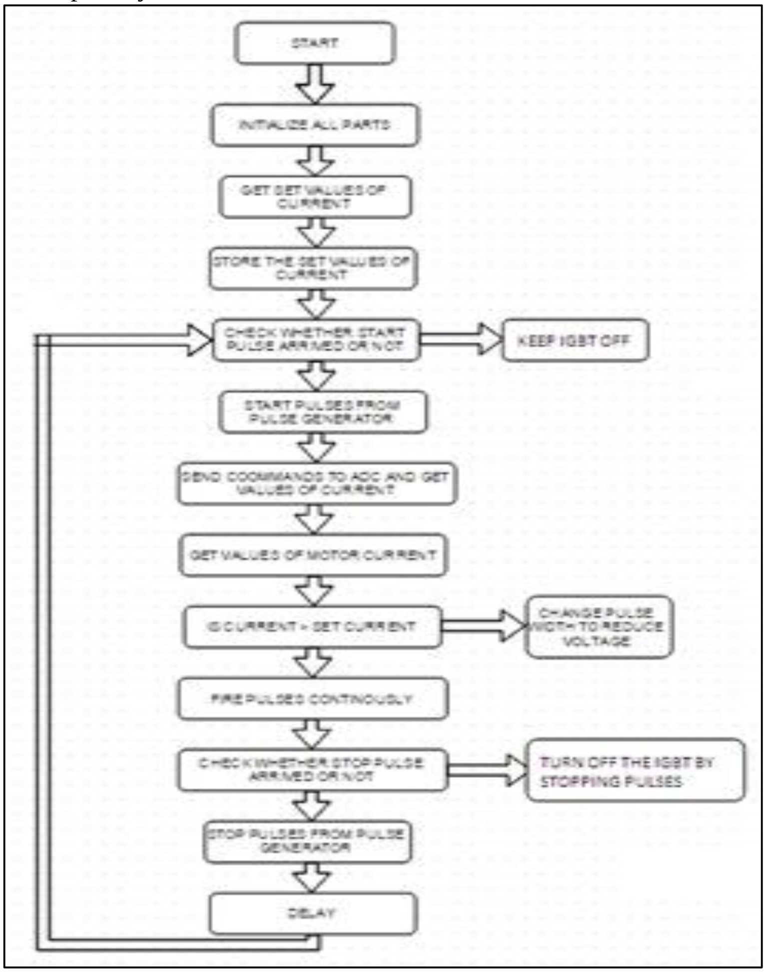

Fig. 3: Microcontroller Flowchart

Input data from current sensors fed to the microcontroller .First microcontroller initialize all the parts then after it takes current present values from current sensors thereby sets the value of current. It stores the set value of current in the data memory of microcontroller. It checks whether all the pulses are given to the thyristor or IGBT , or not .If it is given then it commands the pulse generator to start pulses otherwise it kept IGBT off. Microcontroller again give command to analog to digital converter (ADC) to give the value of current. Microcontroller uses a conditional statement for the current so that if current is greater than set value of current , then it checks whether stop pulse arrived or not otherwise it changes the pulses from the pulse generator and thereby changing the supply voltage of the motor. Pulse generator stop sending the pulses if stop pulse is arrived at respective IGBT otherwise it turn off the IGBT thereby stopping the Induction motor operation

VI. PWM AC CHOPPER

Pulse Width Modulation, as it applies to motor control, is a way of delivering energy through a succession of pulses rather than a continuously varying (analog) signal. To make use of the advantages of both Power MOSFET and Bipolar Junction Transistor (BJT), the IGBT has been introduced. It’s a functional integration of Power MOSFET and BJT devices in monolithic form. It combines the best attributes of both to achieve optimal device characteristics.

VII. EXECUTION OF MAT LAB SIMULINK MODEL

A. OPEN LOOP PWM AC CHOPPER

The performance of the PWM AC chopper is observed under open loop condition in this section. The PWM AC chopper circuit is simulated using MATLAB/Simulink. The simulation results are presented.

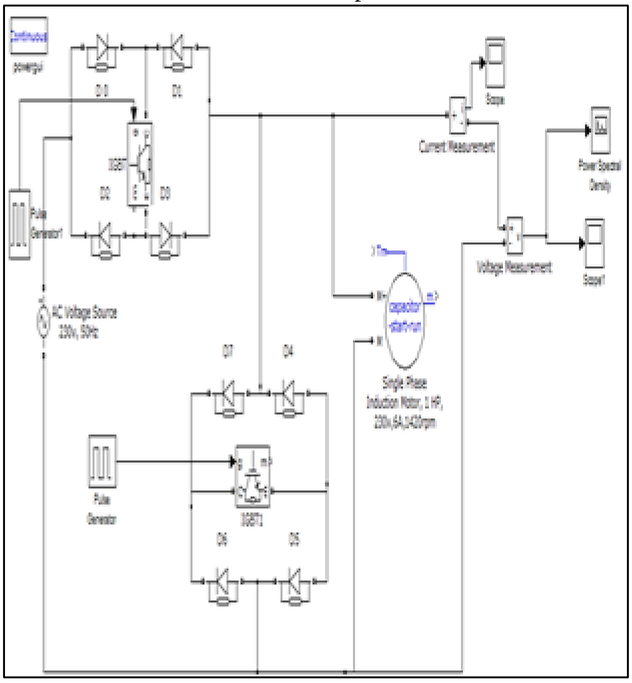

Fig. 4: Open loop PWM AC chopper simulation circuit

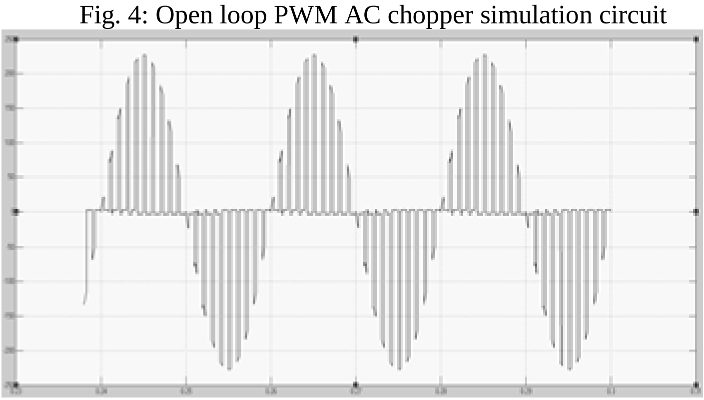

Fig. 5: Voltage waveform of open loop PWM AC chopper for 30% duty cycle supply given to the motor

P = 69 *0.1*0.875*24

P = 0.12KWh

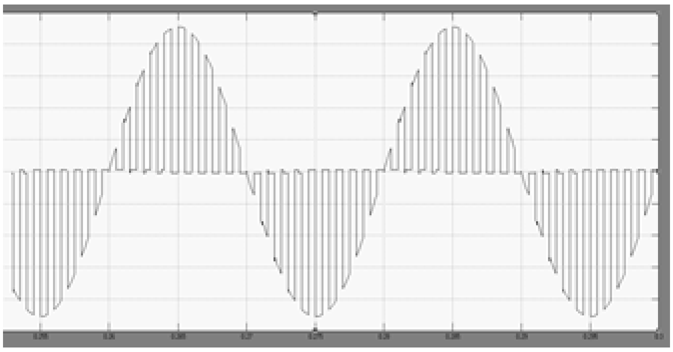

Fig. 6: Voltage waveform of open loop PWM AC chopper for 50% duty cycle

P = 113*0.3*0.875*24
P = 0.724 KWh

B. CLOSED LOOP PWM AC CHOPPER

The performance of the PWM AC chopper is observed under closed loop condition in this section. The PWM AC chopper circuit is simulated using MATLAB/Simulink. Close loop system is different from open loop in many aspects for example close loop system uses a PI controller to control the duty cycle of pulses from both the pulse generator connected to its respected IGBT. Since it is a close loop system motor speed act as a feedback which is given to the PI controller. In PI controller constant is set based on that it changes the supply voltage of the machine.

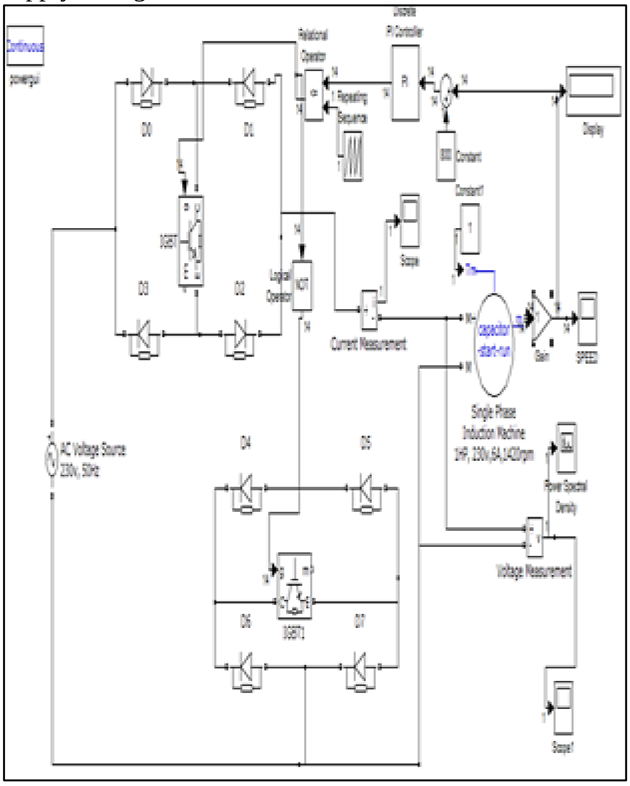

Fig. 7:Close loop PWM AC chopper simulation circuit

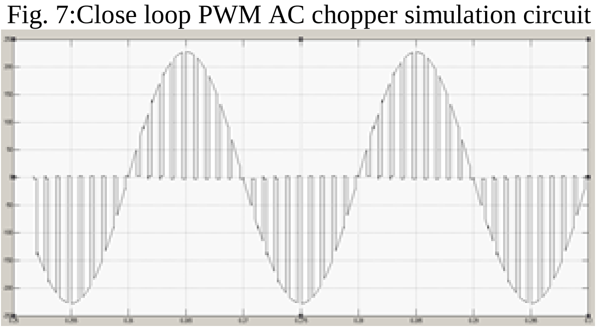

Fig. 8: Voltage waveform of Close loop PWM AC chopper for 70% duty cycle

70% duty cycle
P = 161 *0.35*0.875*24
P = 1.183KWh

VIII. CONCLUSION

In this work, a microcontroller based speed Drive of single phase induction motor was developed. The mat lab Simulink program was used to study the hardware model of speed control of induction motor. This system implemented on induction motor in open loop condition, close loop condition and controlling of stator side voltage which in turn reduce the rotor speed under no load condition is achieved successfully in software system. The Induction motor stator voltage control is an ideal low-cost solution to industrial drive system, where continuous loading and no loading conditions are required. blocking the supply voltage of all induction machine when they are not actually work on job (i.e. during the time lag between operator take out the finished job and put new raw material).The industry will save appreciable amount of voltage as well as overall power (V*I) of plant. The implemented drive control technique is ideal for use in punching and drilling industrial application.

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