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Speed Control of Single Phase Induction Motor Using AC Chopper by Asymmetrical PWM

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Abstract: ***In all home appliances and in small scale industries, single phase induction motors are most commonly used. Recently remarkable efforts have been made in adjustable speed - single phase induction motor drives (SPIMD's). Different types of PWM strategies have been used in speed control of SPIMD's, most widely sinusoidal PWM & space vector PWM strategies. Various converter technologies are taking a place in SPIMD's because of its low cost. The proposed system describes the several PWM strategies with an AC chopper to control the speed of single phase induction motor. Asymmetrical PWM technique has been used to operate the power electronics switches (Triac) of an AC chopper. The main objective of this work is to make the speed of the single phase induction motor varying as per the required load conditions by using Asymmetrical PWM technique, which reduces the harmonic contents in motor and increasing the motor efficiency. The simulation is carried out in MATLAB/SIMULINK with a Split Phase Induction Motor, where the motor is operated in normal PWM strategy and Hysteresis PWM strategy. The hardware is designed for the Asymmetrical PWM technique and results have been obtained.***

Keywords— *AC Chopper, Asymmetrical PWM, Single Phase Induction Motor, Speed Control, Zero crossing.*

1. Introduction

This work presents the simulation part of project "speed control of l phase induction motor using ac chopper by asymmetrical PWM". Our aim is that "By varying the % pulse width we can control the speed of the induction motor i.e. For different PW we have different speed of induction motor as well as on and off time are depended on PW".The IGBT switches of ac chopper are operated by PWM techniques. Single phase induction motor are commonly used in home appliance and small scale industries. So it will be great achievement in technical area of our daily life. The simulation is performed in MATLAB and split phase induction motor is used. Use of ac chopper can also achieve the constant speed at different PW. we can use ac chopper by asymmetrical PWM. The asymmetrical PWM techniques reduces the harmonic content in motor current and increases the motor efficiency. Harmonics generated by speed control unit are filtered by an input filter according harmonic current emissions standards. Conventional methods for starting and speed control of single-phase induction motor need often quite expensive external electrical equipment. Moreover, they require mechanical switches, which are the most troublesome parts. These switches suffer from mechanical wear and tear, which affects the motor performance. Electronic methods based on using a triac in series with the stator main winding or using four triac in a bridge topology has been suggested to control the speed of the motor. Starting of the motor is done by a capacitor with the auxiliary winding. In the literature few

authors have suggested and analyzed the performance of single-phase induction motors fed from inverter circuits with space vector PWM. In this system, either single-phase inverter is used with permanent capacitor motors or two phase inverter is used when the capacitor is not used. Both methods need complicated circuits and not economical. AC chopper is an acceptable solution when a wide range of speed control is required. AC chopper is the advance method of the triac which are used to obtain variable RMS voltage from fixed AC source. It is used in the application such as light dimmers, industrial heating furnaces and induction motor speed controllers. The different type of PWM technique such as conventional PWM, asymmetrical PWM, symmetrical PWM etc, is used to drive the AC Chopper. The hysteresis PWM technique offers a comparatively clean output voltage waveform at high power factor and less harmonic distortion factor of the motor current. A large number of motors are being used for general purposes in our surroundings from basic house hold equipments to machine tools used in industrial applications. The electric motor is now a necessary and indispensable source of power in many industries. The working and the applications of these motors are wide-ranging. For the many applications, the speed control of the motor plays a vital role, which can be done using a wide range of control techniques. The purpose of a motor speed controller is to take a signal representing the demanded speed, and to drive a motor at that speed. The controller may not actually measure the speed of the motor. If it does, it is called a Feedback Speed Controller or Closed loop Speed Controller, if not it is called an open loop Speed Controller. Feedback speed control is better, but it is complicated, and may not be required for a simple design. Generally speed control of the motor can be achieved by varying the input parameters of the motor such as current, voltage. This can be achieved by various methods such as field control method, armature control method, Ward-leonard method etc for DC motors and AC motors, by the improvement of the power electronic devices, the flow of power to the motor is controlled by the switching action of the power switches (MOSFET, IGBT, IGCT etc). The nature of the speed control requirement for an industrial drive application depends upon its type. Some drives may require continuous variation of speed throughout the operation, which ranges from zero to full speed, or a over a portion of the range. For most of the drives, however a control of speed within the range of ±l0% of rated speed may be suitable.

II. DESIGN

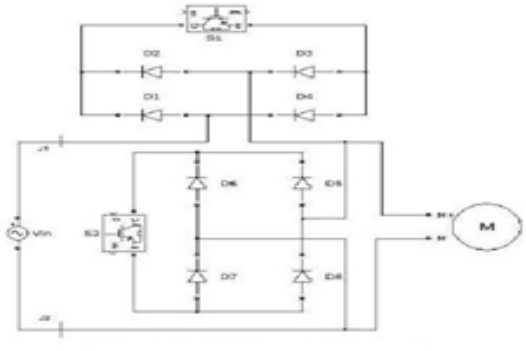

FIG: 1 ASSYMMETRICAL PWM CIRCUIT

Components and their ratings used in simulation :

Ac supply : 230v,50hz

Power diode(RC Snubber) – 230 V , V_f = 0.8 V ,R_s = 500 ohm, C_s = 250 nf

IGBT(RC snubber) – l2v, V_f = lv ,R_s = le5 ohm , C_s =in f

l phase IM (Split Phase)

Nominal voltage(V_n rms) =110v,

f = 60HZ , np =0.25*746 w

Power diode(rc snubber):

Power diode have high voltage and current characteristics. A power diode is a standard diode with much higher current rating. The higher current usually comes at the cost of larger forward

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voltage. Due to high current and and voltage characteristics they can be used in freewheeling diodes and snubber networks. We have current rating of lA for l.l V forward voltage. So for 0.8 v_f we have 0.727A. Forward voltage is the voltage drop across the diode. A simple RC snubber uses a small resistor in series with small capacitor. RC snubber circuits are generally used in electrical system with an inductive load where the sudden interruption of current flow leads to sharp rise in voltage across the current switching device in accordance with faraday's law. If the voltage generated across the device is beyond what the device is intended to tolerate, it may damage or destroy it. The snubber provides the short term alternative path around the current switching device so that the inductive element may be safely discharge.

So we choose to use power diode with RC snubber because our supply is single phase ac supply, 230v and the load is single phase induction motor (inductive load). The power diode have large p-n junction area as a result they have higher forward bias current carrying capacity. In our main circuit diagram proposed (ac chopper) we can see that +ve of ac supply is given to anode of dl which will lead to forward voltage as the anode voltage is more positive then cathode volage. So it leads to large forward voltage which further leads to large forward current and as a result power diode can carry the higher forward bias current easily. We are using inductive load and when there is sudden interruption of current flow, this leads to sharp rise in voltage across the current switching device. If the voltage generated is high then RC snubber circuit will provide the path so that the inductive element is safely discharged and our device is protected from proper heat dissipation.

IGBT with Snubber

We have used IGBT because of following advantages :IGBT is easy to turn on and off. The switching frequency of IGBT is greater than that of power BJT. Exhibits low on state power dissipation. IGBT have easy driver circuit. We have current rating of lA for l.lV forward voltage. So for l v we have 0.909A.

Importance of sunbber in IGBT

The trapped energy in the circuit stray inductance is dissipated in the switching device when a power device is abruptly turned off which cause a voltage overshoot across the device. Magnitude of the transient voltage is proportional to the quantity of stray inductance and the rate of fall or turn off current. For fast switching of IGBT modules the condition is very worst. The devices switch at a high magnitude of currents in a short duration of time, giving rise to potentially destructive voltage transients. The higher current modules normally consist of several IGBT chips in parallel. Each different chip switches share of the load current at a (di/dt) that is determined by the gate drive circuit. The total current and di/dt seen by the external power circuit is the sum of currents and di/dts through each IGBT chip. The di/dts produced could easily be a few thousand thus a Proper attention needs to be paid to protect these devices from destruction. It is determined that the snubbers Offer optimized protection against voltage transients during the normal turn-on and turn-off switching states. Usage of such protection circuits allow faster and safer operation by containing the operating loci within the boundaries of the rated Safe operating Area.

III INPUT AND OUTPUT OF DESIGN

Input is l phase 230v ac. The AC chopper is used to control the speed of Induction Motor by asymmetrical PWM .

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Formulae used :

Output voltage (Vo) = (ton / (ton + toff)) * Vs

Time (T) = ton + toff

Duty cycle (A) = (ton / (ton + toff))

Slip(S) = ((Ns-Nr) / Ns)

Ns = (l20f / p)

P = 4 (given in motor which we have used)

F = 60HZ (as per American standard as we have used in matlab)

Nr = rotor speed which we will get for different pw in graph.

Calculations:

Ns = l20f/p = l800 rpm

Nr for 60% duty cycle = l080rpm

Slip(s) = 0.4

Vo = 0.6*230= l38v

Nr for 90% duty cycle = l200rpm

Slip(s) = 0.333

Vo = 0.9*230 = 207v

IV SIMULATION

Simulation is an animitation of the operation of a real world process or system. The act of simulating something first requires that a model be developed this model represents the key characteristics behaviours and functions of the selected Physical or abstract system or Process. MATLAB, Simulink simulation has been performed for the proposed system and obtained the promising results.

Components Used

[1] Power gui.
[2] AC voltage source.
[3] Voltage measurement.
[4] Pulse generator.
[5] Not logic operator.
[6] Step.
[7] Diode.
[8] Igbt.
[9] Single Phase Asynchronous Machine
[10] Bus selector
[11] Gain
[12] Scope

Power gui: To supply power to our connection we use power gui.

AC voltage source: Our input supply is l phase ac supply.

Voltage measurement: We use voltage measurement to connect the both ends of source and give it to output scope as output scope will be connected only with one line. It also measures the voltage.

Pulse generator: We use pulse generator to generate the pulse. Pulse width can be given here as per our requirement. The pulse type is time based, time(t) is use simulation time, amplitude is l2 ,period (secs) is l/300, phase delay of 0 sec. Phase delay, in contrast, is the time delay of the phase as opposed to the time delay of the amplitude envelope.

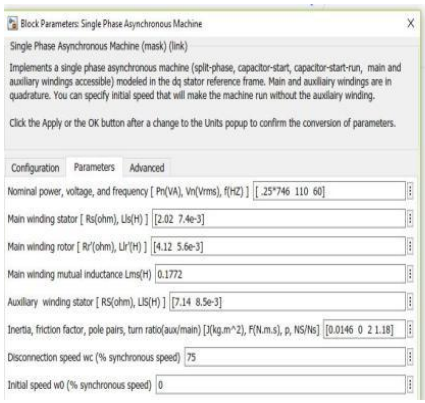
NOT logic operator: We are using not logic operator for remaining toff pw so that it get converted to l and can be supplied to IGBTl as IGBTl operates when input fed to it is l. IGBT and IGBTl are two different IGBTS used in ac chopper(figl)

STEP: Step time is 0, initial time is 0, final value is 0.4, sample time is 0 .

Step is nothing but we are supplying a constant load to the IM .

DIODE and IGBT: The diode and igbt are explained in design part .

Single phase Asynchronous machine(split phase): This is the motor we have used and its parameter are listed below :



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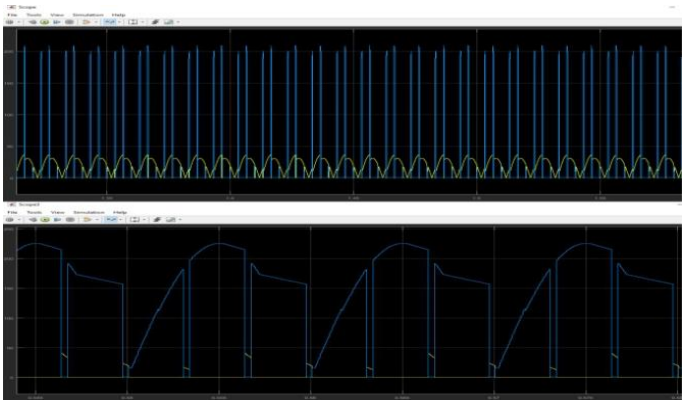
Bus Selector : We are using bus selector because the motor output is mechanical output which is available in bus and only one line is connected because we are displaying only rotor speed in scope

Gain : We are using gain to convert rad/s to rpm (30/pi).

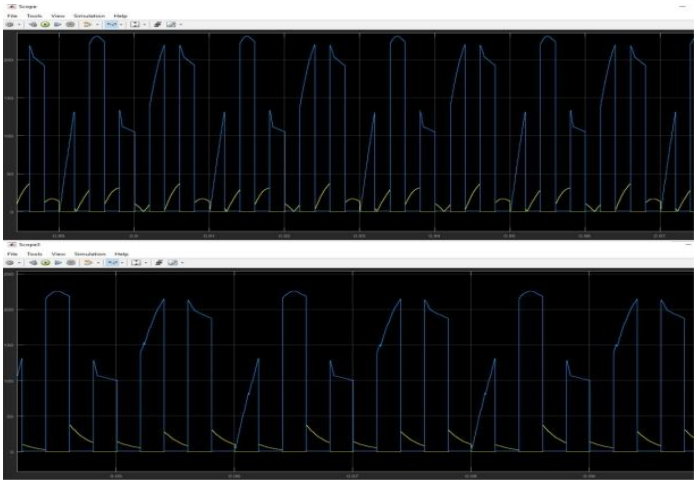
Scope : It is just used to display the output.

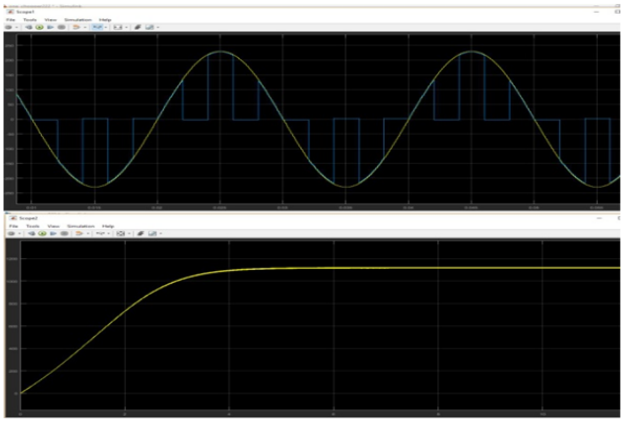
V SIMULATION RESULT

For 90%PW



For 60% PW





VI CONCLUSION

Simulation part of our project is successfully completed. Our aim was to achieve the speed control of induction motor using ac chopper by asymmetrical PWM and we have achieved it. We have used two different PW ie. 60% and 90% . For 60% pw we can see the speed is less than 90% pw. So we can say that the speed is directly proportional to pw, when the pw is high speed is high when the pulse width is low speed is low. The main advantage of our project is that we can save lots of power by running the motor as per the requirement only As lphase induction motor is widely used in small industries and home appliance this project will make great impact on our daily life. AC chopper is an static converter which converts fixed ac to variable ac. So ac chopper makes great impact on ac components/devices by improving the working style of that particular ac component. During our project we came across importance of using snubber circuits with diode and IGBT.We came across different parameters which we were not familier with.The importance of snubber circuit with diode is that it allows path for over voltage so that inductive element can safely discharge and our circuit can be protected. The importance of snubber in circuit in IGBT is that it protect against transient voltage during normal turn onn and turn off.

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