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PFC OF THREE PHASE PWM AC CHOPPER FED IM DRIVE SYSTEM

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Abstract

In this paper, a new control strategy for an induction motor (IM) drive system fed from threephase pulse width modulation (PWM) AC chopper is proposed. The main objective of the proposed control scheme is to achieve input power factor correction (PFC) of the IM drive system under different operating conditions. PFC is achieved by continuously forcing the actual three-phase supply currents with the corresponding reference currents, which are generated in phase with the supply voltages, using hysteresis band current control (HBCC) technique. The proposed control strategy has two loops; inner and outer loop. Output of the outer loop is the magnitude of the supply reference current resulting from either speed controller or startup controller, whereas output of the inner loop is PWM signals of the AC chopper. The proposed AC chopper features a smaller number of active semiconductor switches; four IGBTs, with only two PWM gate signals. As a result, the proposed system is simple, reliable, highly efficient and cost-effective. Mathematical analysis of the drive system is presented. Components of the input LC filter are designed using frequency response. The IM drive system is modeled using MATLAB/SIMULINK and a laboratory prototype was built and tested. Simulation and experimental results confirm validity and robustness of the proposed control strategy.

The First Chapter: An Overview

The most common kind of electric motor seen in commercial applications is an induction motor. There is no kickstart circuit required. Induction motors are the electric motors that have seen the most widespread use in the business world. A starting circuit is unnecessary. Due to the highly inductive nature of the motor, the power factor is initially fairly low. Thus, reactive power is the most useful element in raising the power factor of the system while a motor is being started. Initiating a motor strategy has drawn scientific attention in recent years. Methods for starting induction motors include the Direct On-Line technique, Star-delta, Auto-transformer, soft starter, and variable frequency drive (VFD). The negative effects of a low power factor may be analyzed and mitigated in a variety of ways. In this discussion, we suggest feeding the IM with a three-phase pulse width modulation (PWM) alternating current chopper (voltage regulator).

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The approach presented here is intended to do power factor correction (PFC) in an IM system. We have employed the HBCC (Hysteresis Band Current control) technology, which is activated by comparing the actual current to the reference current, to accomplish this. Following is a breakdown of how the paper is structured.

1.1 Pulse-Width Modulated AC Chopper

Because of the variable voltage amplitude it produces, an AC chopper or AC regulator may also be thought of as a voltage regulator. This approach utilizes a small and dependable chopper that usesjust four IGBTs. The proportion of duty to

By adjusting the RMS value of the motor voltage, the chopper IGBTs are able to fine-tune the motor's voltage and hence its speed.

Ac copter has a duty ratio of D= Ton/Tsw.

Tsw = Ton + Toff, where Tsw is the switching time. Tsw = 1/Fsw is the formula used to determine the Tsw.

The chopper's switching frequency,denoted by Fsw.

Gate pulses for the IGBTs are created using HBCC.

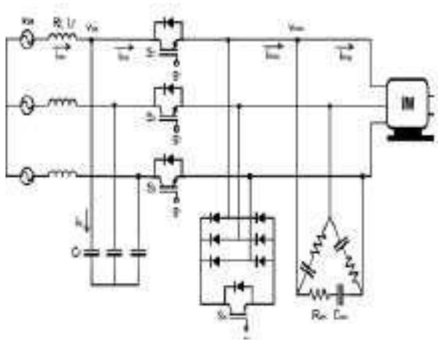

Fig-1.1: AC chopper diagram

Fig. 1.1 depicts the AC chopper setup used in the proposed approach. The energy stored in the induction motor winding is discharged when switches S1, S2, and S3 are connected to the motor and switch S4 is connected in parallel with the universal bridge for freewheeling purposes. For the purpose of dampening voltage spikes at the stator of an induction motor, a three-phase snubber circuit in delta connection is planned out with resistance Rsn per phase and capacitance Csn per phase.

Section 1.2: The Hysteresis Band Constant regulation of currents

PWM is a method for reducing the influence of background noise on the input signal. The states of semiconductor elements are switched using pulse width modulation (PWM) technology. Pulse width modulation (PWM) is the manipulation of pulse width to modulate the output. When it comes to quieting down an AC chopper, HBCC is the control method of choice.

PWM's HBCC technique allows for instantaneous feedback current regulation. The real current follows the command current in a certain hysteresis band using

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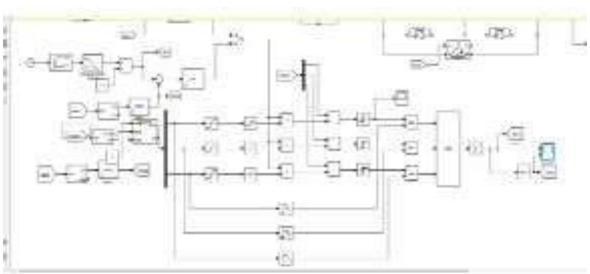
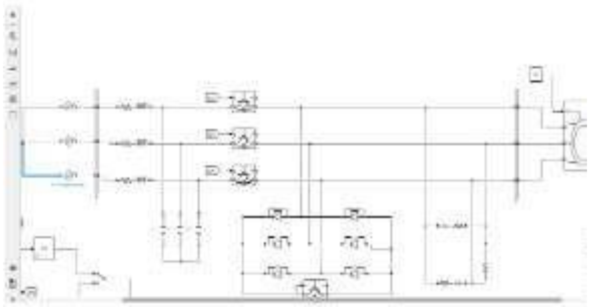
this technique. A reference sine wave of the required amplitude and frequency iscreated by the control circuit, and the phase currents of the motor are compared to it. When the current exceeded the hysteresis range, the switches closed, and vice versa. Currents are compelled to follow the sine wave reference in the hysteresis range selected.

Modeling and Simulation

3.1 Modeling the Logic of Controls –



3.2 Power circuit simulation-



FUZZY CONTROLLER

"Fuzzy control" and "Fuzzy Control" redirect here. For the rock band, see Fuzzy Control (band) A fuzzy control system is a control system based on fuzzy logic—a mathematical system that analyzes analog input values in terms of logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0 (true or false, respectively) Fuzzy logic is widely used in machine control. The term "fuzzy" refers to the fact that the logic involved can deal with concepts that cannot be expressed as the "true" or "false" but rather as "partially true". Although alternative approaches such as genetic algorithms and neural networks can perform just as well as fuzzy logic in many cases, fuzzy logic has the advantage that the solution to the problem can be cast in terms that human operators can understand, so that their experience can be used in the design of the controller. This makes it easier to mechanize tasksthat are already successfully performed by humans History and applications

Fuzzy logic was proposed by Lotfi A. Zadeh of the University of California at Berkeley in a 1965 paper.[3] He elaborated on his ideas in a 1973 paper that introduced the concept of "linguistic variables", which in this article equates toa variable defined as a fuzzy set. Otherresearch followed, with the first industrial application, a cement kiln built inDenmark, coming on line in 1975.

Fuzzy systems were initially implemented in Japan.

Interest in fuzzy systems was sparked by Seiji Yasunobu and Soji Miyamoto of Hitachi, who in 1985 provided simulations that demonstrated the feasibility of fuzzy control systems for the Sendai Subway. Their ideas were adopted, and fuzzy systems were used to control accelerating, braking, and stopping when the Namboku Line opened in 1987.

In 1987, Takeshi Yamakawa demonstrated the use of fuzzy control, through a set of simple dedicated fuzzy logic chips, in an "inverted pendulum" experiment. This is a classic control problem, in which a vehicle tries to keep a pole mounted on its top by a hinge upright by moving back and forth. Yamakawa subsequently made the demonstration more sophisticated by mounting a wine glass containing waterand even a live mouse to the top of the pendulum: the system maintained stability in both cases. Yamakawa eventually went on to organize his own fuzzy-systems research lab to help exploit his patents in the field.

Japanese engineers subsequentlydeveloped a wide range of fuzzy systems for both industrial and consumer applications. In 1988 Japan established the Laboratory for International Fuzzy Engineering (LIFE), a cooperative arrangement between 48 companies to pursue fuzzy research. The automotive company Volkswagen was the onlyforeign corporate member of LIFE, dispatching a researcher for a duration of three years.

Japanese consumer goods oftenincorporate fuzzy systems. Matsushita vacuum cleaners use microcontrollers running fuzzy algorithms to interrogate dust sensors and adjust suction power accordingly. Hitachi washing machines use fuzzy controllers to load-weight, fabric-mix, and dirt sensors and automatically set the wash cycle for the best use of power, water, and detergent.

Canon developed an autofocusing camera that uses a charge-coupled device (CCD) to measure the clarity of the image in six regions of its field of view and use the information provided to determine if the image is in focus. It also tracks the rate of change of lens movement during focusing, and controls its speed to prevent overshoot. The camera's fuzzy controlsystem uses 12 inputs: 6 to obtain the current clarity data provided by the CCD and 6 to measure the rate of change of lensmovement. The output is the position ofthe lens. The fuzzy control system uses 13 rules and requires 1.1 kilobytes ofmemory.

An industrial air conditioner designed by Mitsubishi uses 25 heating rules and 25 cooling rules. A temperature sensor provides input, with control outputs fed to an inverter, a compressor valve, and a fan motor. Compared to the previous design, the fuzzy controller heats and cools five times faster, reduces power consumption by 24%, increases temperature stability by a factor of two, and uses fewer sensors.

Other applications investigated or implemented include: character and handwriting recognition; optical fuzzy systems; robots, including one for making Japanese flower arrangements; voice-controlled robot helicopters (hovering is a "balancing act" rather similar to the inverted pendulum problem); rehabilitation robotics to provide patient-specific solutions (e.g. to control heart rate and blood pressure [4]); control of flow of powders in film manufacture; elevator systems; and so on.

Work on fuzzy systems is also proceeding in North America and Europe, although on a less extensive scale than in Japan.

The US Environmental Protection Agency has investigated fuzzy control for energy-efficient motors, and NASA has studied fuzzy control for automated space docking: simulations show that a fuzzy control system can greatly reduce fuel consumption.

Firms such as Boeing, General Motors, Allen-Bradley, Chrysler, Eaton, and Whirlpool have worked on fuzzy logic for use in low-power refrigerators, improved automotive transmissions, and energy-efficient electric motors.

In 1995 Maytag introduced an "intelligent" dishwasher based on a fuzzy controller and a "one-stop sensing module" that combines a thermistor, for temperature measurement; a conductivity sensor, to measure detergent level from the ions present in the wash; a turbidity sensor that measures scattered and transmitted light to measure the soiling of the wash; and a magnetostrictive sensor to read spin rate. The system determines the optimum wash cycle for any load to obtain the best results with the least amount of energy, detergent, and water. It even adjusts for dried-on foods by tracking the last time the door was opened, and estimates the number of dishes by the number of times the door was opened.

In 2017 Xiera Technologies Inc. developed the first auto-tuner for the fuzzy logic controller's knowledge base known asedeX. This technology was tested by Mohawk College and was able to solve non-linear 2x2 and 3x3 multi-input multi- output problems.[5]

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Research and development is also continuing on fuzzy applications in software, as opposed to firmware, design, including fuzzy expert systems and integration of fuzzy logic with neural-network and so-called adaptive "genetic" software systems, with the ultimate goal of building "self-learning" fuzzy-control systems.[6] These systems can be employed to control complex, nonlinear dynamic plants,[7] for example, human body.[4][6][8]

Fuzzy sets

See also: fuzzy set

The input variables in a fuzzy control system are in general mapped by sets of membership functions similar to this, known as "fuzzy sets". The process of converting a crisp input value to a fuzzy value is called "fuzzification". The fuzzy logic based approach had been considered by designing two fuzzy systems, one for error heading angle and the other for velocity control.[9]

A control system may also have various types of switch, or "ON-OFF", inputs along with its analog inputs, and such switch inputs of course will always have a truth value equal to either 1 or 0, but the scheme can deal with them as simplified fuzzy functions that happen to be eitherone value or another.

Given "mappings" of input variables into membership functions and truth values, the microcontroller then makes decisions for what action to take, based on a set of "rules", each of the form:

IF brake temperature IS warm AND speed IS not very fast

THEN brake pressure IS slightly decreased.

In this example, the two input variables are "brake temperature" and "speed" that have values defined as fuzzy sets. The output variable, "brake pressure" is also defined by a fuzzy set that can have values like "static" or "slightly increased" or "slightly decreased" etc.

Fuzzy control in detail

Fuzzy controllers are very simple conceptually. They consist of an input stage, a processing stage, and an output stage. The input stage maps sensor or other inputs, such as switches, thumbwheels, and so on, to the appropriate membership

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functions and truth values. The processing stage invokes each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result backinto a specific control output value.

The most common shape of membership functions is triangular, althoughtrapezoidal and bell curves are also used, but the shape is generally less important than the number of curves and theirplacement. From three to seven curves are generally appropriate to cover the required range of an input value, or the "universe of discourse" in fuzzy jargon.

As discussed earlier, the processing stage is based on a collection of logic rules in the form of IF-THEN statements, wherethe IF part is called the "antecedent" and the THEN part is called the "consequent". Typical fuzzy control systems have dozens of rules.

Consider a rule for a thermostat:

IF (temperature is "cold") THEN turn (heater is "high")

This rule uses the truth value of the "temperature" input, which is some truth value of "cold", to generate a result in the fuzzy set for the "heater" output, which is some value of "high". This result is used with the results of other rules to finally generate the crisp composite output. Obviously, the greater the truth value of "cold", the higher the truth value of "high", though this does not necessarily mean that the output itself will be set to "high" since this is only one rule among many. In some cases, the membership functions can be modified by "hedges" that are equivalent to adverbs. Common hedges include "about", "near", "close to", "approximately", "very", "slightly", "too", "extremely", and "somewhat". These operations may have precise definitions, though the definitions can vary considerably between different implementations. "Very", for one example, squares membership functions; since the membership values are always less than 1, this narrows the membership function. "Extremely" cubes the values to give greater narrowing, while "somewhat" broadens the function by taking the square root.

In practice, the fuzzy rule sets usually have several antecedents that are combinedusing fuzzy operators, such as AND, OR,

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and NOT, though again the definitions tend to vary: AND, in one popular definition, simply uses the minimum weight of all the antecedents, while ORuses the maximum value. There is also a NOT operator that subtracts a membership function from 1 to give the "complementary" function. There areseveral ways to define the result of a rule, but one of the most common and simplest is the "max-min" inference method, in which the output membership function is given the truth value generated by the premise

Rules can be solved in parallel in hardware, or sequentially in software. The results of all the rules that have fired are "defuzzified" to a crisp value by one of several methods. There are dozens, in theory, each with various advantages ordrawbacks.

The "centroid" method is very popular, in which the "center of mass" of the result provides the crisp value. Another approach is the "height" method, which takes the value of the biggest contributor. The centroid method favors the rule with the output of greatest area, while the height method obviously favors the rule with the greatest output value.

The diagram below demonstrates max-min inferencing and centroid defuzzification for a system with input variables "x", "y", and "z" and an output variable "n". Note that "mu" is standard fuzzy-logic nomenclature for "truth value":

4. RESULTS

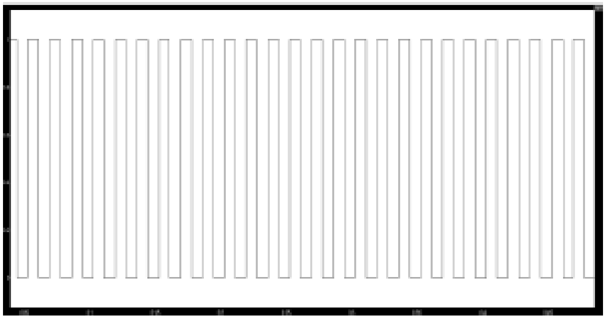

Fig-4.1:Gate Pulse 1

Fig 4.1 and 4.2 shows gate pulses generated for IGBT's operation by using HBCC pwm method for AC chopper

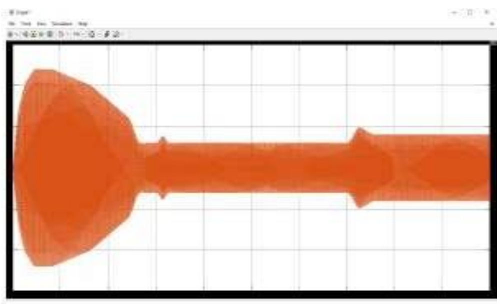

Fig- 4.3: Motor Current

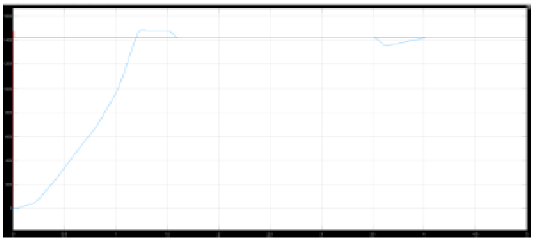

Fig-4.4: Wm (speed of motor)

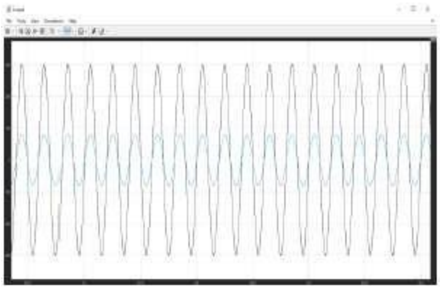

Fig-4.5: chopper voltage and current ouput

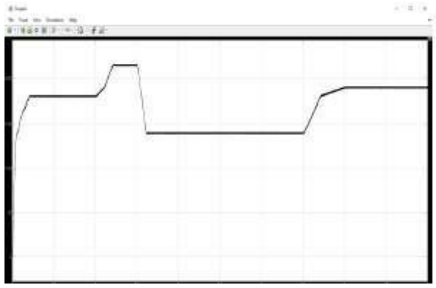

Fig -4.6: Vma(output motor voltage)

IV. SUMMARY

Accurate power factor under varying induction motor running conditions is the primary focus of this control technique. By enforcing the actual current to track the reference current within a specified band (HBCC), the input power factor can be corrected, the IGBT chopper can provide the necessary voltage for the motor to operate efficiently and with precisecontrol, and the power factor correction can be accomplished.

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