POWER FACTOR CORRECTION OF THREE-PHASE PWM AC CHOPPER FED INDUCTION MOTOR DRIVE SYSTEM USING HBCC TECHNIQUE

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Abstract In this paper, a new control strategy for an induction motor (IM) drive system fed from three-phase 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: the inner loop and outer loop. The output of the outer loop is the magnitude of the supply reference current resulting from either speed controller or startup controller, whereas the 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 efcient, and cost effective. Mathematical analysis of the drive system is presented. Components of the input LC lter are designed using frequency response. The IM drive system is modeled using MATLAB/SIMULINK, and a laboratory prototype was built and tested. The simulation and experimental results conrm the validity and robustness of the proposed control strategy.

I INTRODUCTION

The cosine of angle between voltage and current in ac circuit is known as power factor

In an ac circuit, there is generally a phase difference between voltage and current.The term cos is called the power factor of the circuit.

POWER FACTOR is the ratio between the useful (true) power (kW) to the total (apparent) power (kVA) consumed by an item of a.c. electrical equipment or a complete electrical installation. It is a measure of how efficiently electrical power is converted into useful work output. The ideal power factor is unity, or one. Anything less than one means that extra power is required to achieve the actual task at hand. All current flow causes losses both in the supply and distribution system.

A load with a power factor of 1.0 results in the most efficient loading of the supply. A load with a power factor of, say, 0.8, results in much higher losses in the supply system and a higher bill for the consumer. A comparatively small improvement in power factor can bring about a significant reduction in losses since losses are proportional to the square of the current. When the power factor is less than one the ‘missing’ power is known as reactive power which unfortunately is necessary to provide a magnetising field required by motors and other inductive loads to perform their desired functions. Reactive power can also be interpreted as wattless, magnetising or wasted power and it represents an extra burden on the electricity supply system and on the consumer’s bill. A poor power factor is usually the result of a significant phase difference between the voltage and current at the load terminals, or it can be due to a high harmonic content or a distorted current waveform.

A poor power factor is generally the result of an inductive load such as an induction motor, a power transformer, a ballast in a luminaire, a welding set or an induction furnace. A distorted current waveform can be the result of a rectifier, an inverter, a variable speed drive, a switched mode power supply, discharge lighting or other electronic loads. A poor power factor due to inductive loads can be improved by the addition of power factor correction equipment, but a poor power factor due to a distorted current waveform requires a change in equipment design or the addition of harmonic filters.

Some inverters are quoted as having a power factor of better than 0.95 when, in reality, the true power factor is between 0.5 and 0.75. The figure of 0.95 is based on the cosine of the angle between the voltage and current but does not take into account that the current waveform is discontinuous and therefore contributes to increased losses. An inductive load requires a magnetic field to operate and in creating such a magnetic field causes the current to be out of phase with the voltage (the current lags the voltage). Power factor correction is the process of compensating for the lagging current by creating a leading current by connecting capacitors to the supply.

A sufficient capacitance is connected so that the power factor is adjusted to be as close to unity as possible.

Power factor correction

Power factor correction is the term given to a technology that has been used since the turn of the 20th century to restore the power factor to as close to unity as is economically viable. This is normally achieved by the addition of capacitors to the electrical network which compensate for the reactive power demand of the inductive load and thus reduce the burden on the supply. There should be no effect on the operation of the equipment. To reduce losses in the distribution system, and to reduce the electricity bill, power factor correction, usually in the form of capacitors, is added to neutralize as much of the magnetizing current as possible.

Capacitors contained in most power factor correction equipment draw current that leads the voltage, thus producing a leading power factor. If capacitors are connected to a circuit that operates at a nominally lagging power factor, the extent that the circuit lags is reduced proportionately. Typically the corrected power factor will be 0.92 to 0.95. Some power distributors offer incentives for operating with a power factor of better than 0.9, for example, and some penalize consumers with a poor power factor. There are many ways that this is metered but the net result is that in order to reduce wasted energy in the distribution system, the consumer is encouraged to apply power factor correction. Most Network Operating companies now penalize for power factors below 0.95 or 0.9.

PULSE WIDTH MODULATION (PWM)

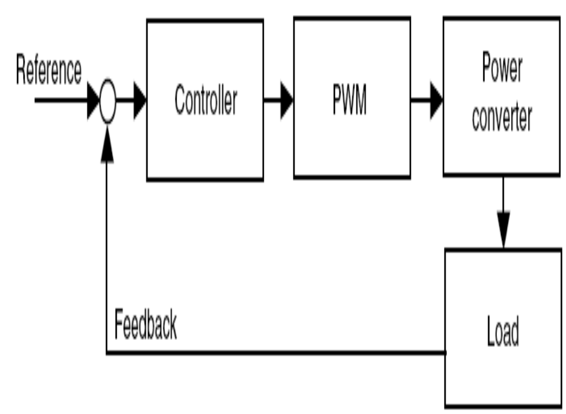
For a dynamic EM vitality collector framework, if the outer excitation recurrence is not quite the same as the inherent reverberation recurrence, the PEI ought to have the capacity to match its data impedance with the inward impedance of the reaper so most extreme force point (MPP) could be followed. This paper proposed once more topology, which has the greatest force point following (MPPT) ability.

In any case, the primary target of this paper is to present the circuit topology, which is fit for fulfilling the voltage prerequisite (3.3 V) of an electronic burden. Hence, a voltage input control circle is used to direct the heap voltage V The streamlined plan of the controller and force stage is represented in Fig.4.1 The converter is intended to work in DCM. The yield voltage is sifted by an inactive low-pass channel and after that encouraged to the simple to-advanced converter (ADC) of the controller.

The distinction between the ADC yield and the coveted voltage is computed and remunerated through the PI calculation to produce a movable obligation cycle signal. The exchanging signs of S1 and S2 are subject to the info's extremity voltage. A sign indicator is utilized to focus the info voltage extremity.

The Atmel Mega 16 An is chosen as the controller in this paper, which has both on-chip simple comparator and coordinated A DC and can be incorporated with the sign indicator. The sign finder is made out of a voltage reference, an operation amp, and the on-chip simple comparator. The operation amp works a simple viper, where a dc inclination (voltage reference) is added to the info voltage. The sign summation is contrasted with the voltage reference with recognize the extremity.

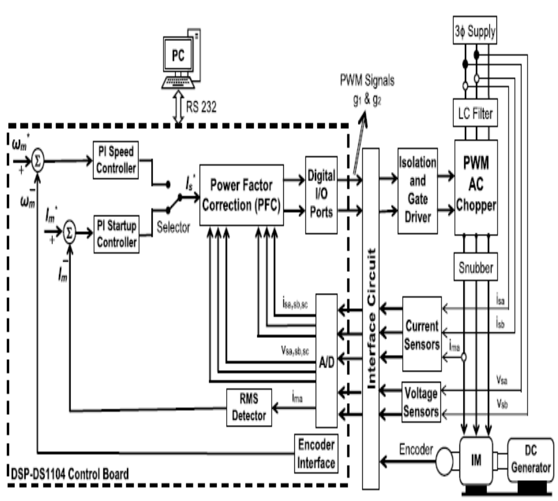
The pwm strategies produce the prerequisite of d.c voltage by looking at the bearer flag and reference signals.



Block diagram of pwm

II PROPOSED CONTROL STRATEGY

The proposed control strategy has three main control objectives: soft starting, speed control, and input power factor correction (PFC). This strategy is depending on the control of the applied voltage across IM terminals using AC chopper. Fig. 3 illustrates the schematic diagram of the proposed control strategy. It has two control loops. The inner control loop uses HBCC to force the chopper actual current signals to track their command current signals to achieve input PFC, whereas the outer control loop determines the magnitude of the reference currents either from starting mode or speed control mode. As a result, the inner loop controls the phase and the outer loop controls the magnitude of the chopper currents. In the rst, the soft starting mode is working, and by giving a switching pulse to the selector switch, the speed control mode is activated and the soft starting mode is turned off.



Block diagram of the proposed control circuit

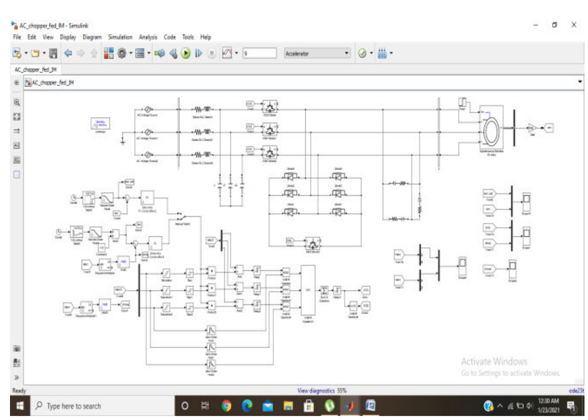
III SOFTWARE USED

MATLAB

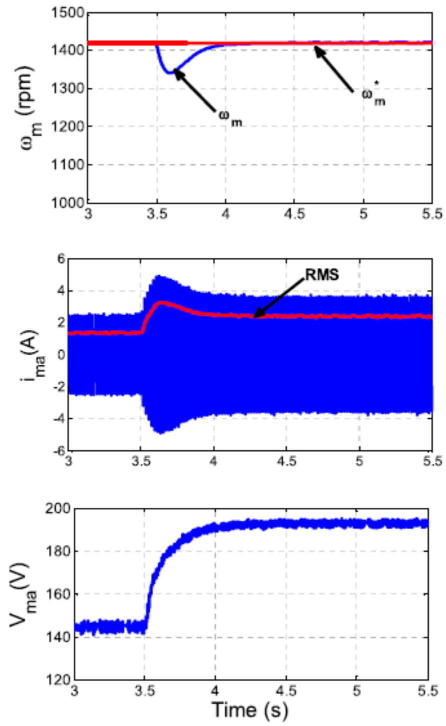
Matlab is a superior dialect for specialized processing. It incorporates calculation, representation, and programming in a simple to-utilize environment where issues and arrangements are communicated in well known numerical documentation. Run of the mill uses incorporate Math and calculation Algorithm advancement Data securing Modeling, reproduction, and prototyping Data examination, investigation, and representation Scientific and designing illustrations Application improvement, including graphical client interface building.

Matlab is an intuitive framework whose fundamental information component is a cluster that does not require dimensioning. This permits you to take care of numerous specialized figuring issues, particularly those with network and vector plans, in a small amount of the time it would take to compose a system in a scalar no intuitive dialect, for example, C or Fortran.

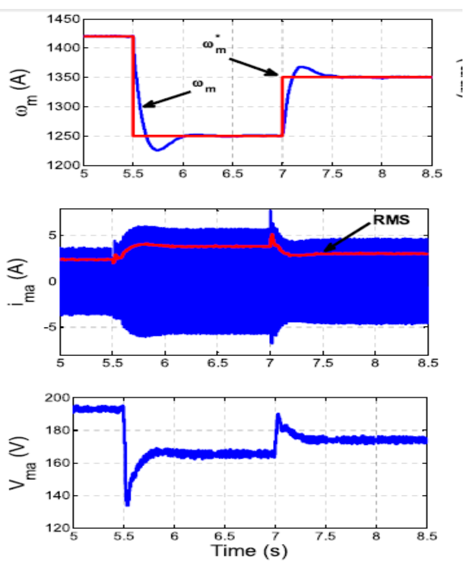
IV SIMULATION RESULTS



Matlab model

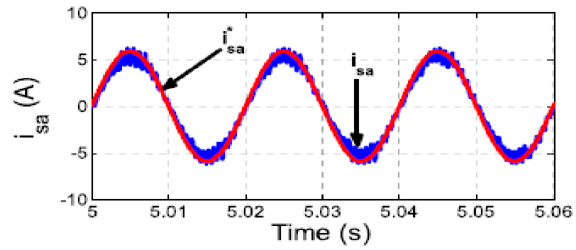


Variation of the motor speed, current and phase voltage at step change in the load torque. (a) Simulation.



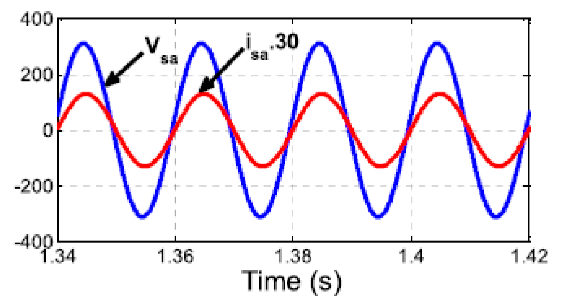
(a)

Variation of the motor speed, current and phase voltage at step change in the reference speed. (a) Simulation.

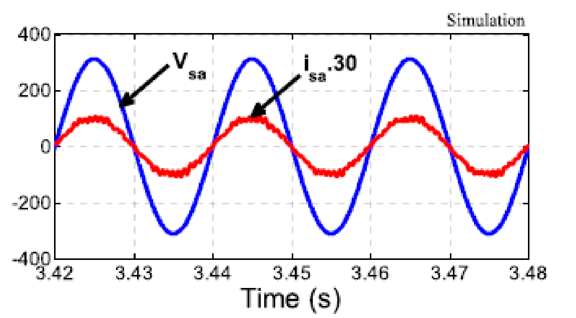


(a)

Reference and measured currents of the supply. (a) Simulation



(a)



(b)

Supply voltage and current at different testing cases of the proposed system. (a) Case 1. (b) Case 2. (c) Case 3.

V CONCLUSIONS

A new control strategy of three-phase squirrel cage IM fed from PWM AC chopper has been simulated and laboratory implemented using dSPACE (DS1104) control board. The main control objective is to correct the input PF with different operating conditions of the induction motor drive system. Input PFC is achieved by forcing the actual currents of the chopper to track their reference currents that are in phase with the input voltages using HBCC technique.

The proposed control strategy uses only two PWM signals for driving the active switches of the AC chopper. The proposed system is simple, reliable and low cost as it has only four IGBT switches. Operation principle and mathematical analysis of the proposed system are introduced. The system was simulated using MATLAB/SIMULINK and a laboratory system was implemented.

The effectiveness of the proposed control strategy has been tested at starting, reference speed change and load torque variation. The obtained results from the experimental and computer simulationworks verify the validity of the proposed control strategy during all testing conditions. Performance of the system without PFC is roughly compared in accordance with concerning the proposed PFC technique during the three test cases. Comparative results illustrate that the system with the proposed PFC technique has a corrected PF and hence a better performance.

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