Industrial Speed Control of IM Based Model Predictive Controller Using Zeta Converter

Balachandra Pattanaik¹, B Barani Sundaram², Manish Kumar Mishra³, Dhanabal Thirumooorthy⁴, Umang Rastogi⁵*
¹Department of Electronics and Communications, Bule Hora University, Bule Hora, Ethiopia
²Department of Computer Sciences, Bule Hora University, Bule Hora, Ethiopia
³Department of Computer Sciences, University of Gondar, Ethiopia
⁴College of Informatics, Bule Hora University, Bule Hora, Ethiopia
⁵Department of Computer Science Engineering, Meerut Institute of Engineering and Technology, Meerut, Uttar Pradesh, India
Email: balapk1971@gmail.com¹, bsundar2@gmail.com², mishrasoft1@gmail.com³, dhanabalnet@gmail.com⁴, umang.rastogi@mit.ac.in⁵*

Abstract: For induction, machine-based configuration, the model predictive control scheme, power converter based renewable system is presented in this paper. The PV system is proposed to provide an input source for the model predictive control (MPC) based system. The control method predictive is used based on vector control. According to this, the drive system behaviour of the fault-tolerant capacity is enhanced. The ZETA converter is proposed to improve the system input source, which fed on the PV system. The proposed ZETA converter is used to increase the DC link voltage of the system. The motor's speed and torque can be controlled by the model predictive control method based on vector control. The results of the proposed system are obtained and verified using the MATLAB/Simulink.

Keywords: Induction Motor (IM), ZETA converter, MPC controller, and PV system.

1. Introduction

The increasing energy shortages worldwide and natural environment degradation have been finding recognition from engineering and science fraternity for many decades. The introduction of rapid switching power electronic devices and the advancement of semiconductor technologies have led greatly to conversion methods. PV based energy generation has preferred electricity generation because it has less cost in panels and utilization of power electronics devices. Awareness has been maturing rapidly for the development of renewable energy sources. Renewable energy utilization is increasing in everyday life and accomplished from natural resources [1]. However, the system is in the process of growth, and several problems need to be solved such as intermittency, high initial cost and poor performance.

In the past decades, the Induction motors performance is highly controlled by DTC and FOC control techniques' popular methods. In the FOC control method, stator in the IM currents is decomposed into d-axis based on the flux, and the component of q-axis based on the induction motor torque [2]. The achievement from these components is rotor flux and torque coupled control. Here the two PI controllers regulate the currents of the two components such as d-axis and q-axis. The SVM block is frequently used for providing gating signals for VSI to synthesize the reference voltage.
vector. The quick dynamic response and steady-state performance are accomplished using field-oriented control (FOC), mostly preferred in industrial drives [3]. In the wide range of industrial based induction motor application, the voltage source converter is majorly used. However, there are failures due to the unbalanced power supply, which is direct to the total converter system lockdown and results in poor maintenance [4]. Direct torque control which is introduced in IM motors latterly it used in all AC machines with converters. The DTC is better because it eliminates the current control and the SVM while compared to FOC. According to the torque error signs and flux of stator, the DTC directly chose the vector voltage from the stator flux switching table position [5].

Due to the multivariable control, dynamic response with quickly, and intuitive concepts makes the MPC an outstanding control. In the IM drives normally the stator flux and torque are elected for the controller variables to improve the performance. In this control, both the flux and torque errors are estimated and evaluated for the voltage vector. The MPC voltage vector system's utilization has accuracy and effectiveness compared with the DTC method of control [6]. The FOC-based satisfaction concern for steady-state performance is not achieved because the voltage vector does not accurately improve the stator flux and torque [7].

In the proposed system, the ZETA converter is regulating the DC supply from the PV arrays. The output of the ZETA is fed to the IM interfaced voltage source converter [8]. The converter output is input to the interfaced VSI, which is controlled by the MPC system. The MPC control is implemented to control the IM stator flux and torque. The operation of the drive controlled according to the response of the proposed controller system. The results are verified and validated through the simulations, and the effectiveness of the system is carried out [9].

2. Proposed System

The proposed system consists of a predictive model controller, pulse width modulation control technique, induction machine, PV array and power ZETA converter. The proposed system is implementing the function of IM speed control. The inverter voltage can be forced by using a model predictive controller. This vector control-based arrangement is used to manage the motor's speed with the MPC algorithm's help.

In this system, the ZETA converter is used to improve the supply voltage (DC voltage) from the renewable PV array. Compared with conventional systems, the ZETA converter increases the output voltage of the converter system fed to the DC-AC converter [10]. The input source is enhancing when the pulse width modulation control controls the converter. The PWM is providing the gate pulses for the proposed ZETA converter to improve the DC bus voltage. The block diagram of the proposed system is shown in Figure 1. The large capacitance is added at the end of the converter output circuit to store the high voltage gain. The gain of the converter is fed to the three-phase inverter.
Normally, the inverter's operation converts the direct voltage supplied from the converter side to the induction machine three-phase voltages to operate the load.

3. ZETA converter
In this system, the ZETA converter is proposed, as shown in Figure 2 to control the DC link voltage regulation [11]. The converter's output response is fed to the inverter, providing AC voltage for the induction motor. The proposed converter comprises two capacitors as well as inductors. High voltage gain is achieved through the power switch duty cycle and dc-link capacitor operation [12]. The converter's operation is when the power switch is conducting; the D is turned to off state than in this charging mode the V_s providing current to the L1 and L2 inductors [13]. During the switch S turned off, D comes to conduction the stored power in the inductor L2 is fed to load.

![Figure 2: circuit of ZETA converter](image)

ZETA is a fourth-order, multi-real, dynamic poles and zeros converter [14]. The ZETA converter has no right-half plane zero except the SEPIC converter. It could be more conveniently offset for greater loop [15] efficiency and improved load transfer performance for lower output power values.

4. Control strategy
The proposed system is implementing for induction motor speed control. The inverter voltage can be controlled by using a model predictive controller. This vector control-based system is used to control the motor's speed with a model predictive algorithm's help. MPC is an innovative approach for the control of a process that satisfies a series of limits. The biggest benefit of MPC is that it makes it easier to refine the existing timeframe while establishing future time frames. For the IM machines control, the MPC is used as shown in Figure 3. In this method, the flux and torque errors are defined by the cost function to derive the best voltage vector. The observer of full order's flux and torque estimation is adopted because of the insensitivity and accuracy to a wide range of speed with parameter variation. The output of the IM is fed to the estimation and prediction of the torque and flux. The actual speed is compared with the reference speed using a comparator. The comparator's output is controlled by a PI controller, which provides the reference of the torque. Then the reference flux and torque are given to the cost function minimization.
5. Simulation and Results
In the proposed system, the induction motor is controlled by the PV system fed ZETA converter, improving the PV voltage supply. The DC link voltage is reaching too high through the PWM signals-based ZETA converter. The converter contains the power switch, inductor, capacitor and diode devices. The model predictive controller (MPC) is utilized to control the IM machine's torque and speed by controlling the stator's voltage and current. The Simulink model of the proposed system is shown in Figure 4. Proposed MPC provides switching signals to the VSI. The IM is powered from the inverter, and the MPC system controls the motor's performance.

The duty cycle of the MOSFET power switch is 0.5. The six power switches of the inverter side are controlled by using the proposed model predictive control. According to this method, the speed of the drive and torque range can be controlled widely. The waveforms for the input voltage, dc bus voltage, inverter voltage, and drive speed are shown in Figure 5.
The proposed drive control system's DC bus voltage is shown in Figure 6, and the proposed inverter can do it. The DC link voltage is fed to the three legs of six switches side. Here, the DC voltage is converted into AC voltage. The amplitude of the AC voltage from the inverter system is 200V for each phase.

Figure 5: Proposed System Input Voltage

Figure 6: DC link bus voltage

The proposed drive control system's DC bus voltage is shown in Figure 6, and the proposed inverter can do it. The DC link voltage is fed to the three legs of six switches side. Here, the DC voltage is converted into AC voltage. The amplitude of the AC voltage from the inverter system is 200V for each phase.
Figure 7: Inverter Output voltage

The voltage source inverter output is shown in Figure 7. The switching signals to the power switches are provided from the MPC control method. The stator current of the induction motor drive is shown in Figure 8 the motor drive stator current is 8.5 A.

Figure 8: Stator Current of induction motor

The proposed system's speed is controlled, and the speed of the induction motor is a reference output of 500 revolutions per minute (RPM). The settling time of the proposed system is 0.8 sec. Figure 9 is showing that the IM drive speed, which is controlled and settled quickly.
6. Conclusion

In this paper, the IM drive based on ZETA converter is designed with the model predictive control method is proposed. The drive speed and efficiency is improved, and the dc supply voltage is improved by ZETA converter. The PV system is proposed to provide an input source for the model predictive control (MPC) based system. The control method predictive is used based on vector control. The results are verified and examined in MATLAB/Simulink, and it shows that motor torque range and speed enlargement. The voltage boosting method and the efficiency of this proposed method are high while compared with traditional systems. The drive speed is achieved at 500 rpm with the proposed control method's help, and the response time of the drive speed is 0.7 sec. The results are obtained and verified using Simulink.

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