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# Design and Development of Five-leg Converter for Three Phase Induction Motor

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**ABSTRACT:** Five-leg inverter is employed to feed dual induction motors for the cost-down of power devices and hardware circuits. In order to realize independent fast control for both IM', a model predictive control (MPC) strategy is developed in this paper. By using this strategy, the following state is predicted by using discrete-time models of the five-leg inverter and two IM's. The switching state, which minimizes the cost function, is selected to be applied in the following sampling period. Simulation results show that the dual induction motor drive system has extremely good static and dynamic performances

## I. INTRODUCTION

Induction motors are the starting point to design an electrical drive system which is widely used In many industrial applications. In modern control theory, different mathematical models describe induction motor according to the employed control methods. Vector control strategy can be applied to this electrical motor type in symmetrical three phase version or in unsymmetrical two phase version [1],[3]. An AC Motor Drives played important role in all field, mostly in industrial application they are mostly used in blower, Pumps, Industrial Fan, Machine tools, Electric Vehicles, etc. In order to operate several motors used in one inverter multilevel drives have been suggested, five leg inverter system[1].

Since multimotored drives are configured with reduces switches as compare with convectional motor drives. They have advantages in terms of size, capital cost, and switching losses.

The five leg voltage source (FLVSI) is one of the examples of multilevel drives that operated dual three phase induction motor name as IM1 and IM2. It has total 6 leg, but we make two leg combine hence it has five leg. It required total ten switch for operating dual induction motor which is comparably less with three level voltage source inverter. Controlling o two motor independently by using FLVSI. Several methods have been adopted is Model practice control method (MPC) [7], [8], [9].

This project is focused on model predictive control. In combination with advancement of microcontroller unit and digital signal processor. The MPC is suitable for application which required fast dynamic response as compare with pulse width modulation. MPC technique is more advantages (FSMPS = Full set model predictive controlled method). Since the FLVSI is configured with five leg considering switches in each leg operated complementary the possible number of switching stated is 32 so that, 32 voltage vectors are considered to select an optimal future voltage vector in FSMPC method [8], [9], [10].

## II. LITERATURE SURVEY

According to the authors Dongho Choi , Student Member, IEEE, June-Seok Lee , Senior Member, IEEE, Young-Seol Lim, Member, IEEE, and Kyo-Beum Lee , Senior Member, IEEE presented in published paper of "Priority-Based Model Predictive Control Method for Driving Dual Induction Motors Fed by Five-Leg Inverter" described that introduction of priority-based model predictive control (PMPC) method for a five-leg voltage source inverter (FLVSI) that independently drives dual three-phase induction motors (IMs). In a FLVSI operated by a MPC method, selecting an optimal future voltage vector among all 32 candidate switching states causes a high computational burden.

According toauthors, M. Stender, O. Wallscheid, Member, IEEE, and J. B'ocker, Senior Member, IEEEpresented in published paper of "Accurate Torque Control for Induction Motors by Utilizing a Globally

**Optimized Flux Observer**” described that introduction of High-precision torque estimation and control of induction motor drives is an important research field due to the extensive use of these motors in torque-controlled applications, for example in electric vehicles. The open-loop torque control performance depends strongly on the accuracy of both the motor model and the flux estimation. To address this appropriately, an adaptive Kalman filter with offline parameter and observer design optimization is proposed in this paper

According to the authors Sunku Kwon, Student Member, IEEE, and Jung-Ik Ha, Fellow, IEEE, presented in published paper of **“Fault-Tolerant Operation under Single-Phase Open in Mono Inverter Dual Parallel SMPMSM with Single Shaft”** described that introduction of fault-tolerant operation for dual three-phase surface-mounted permanent magnet machines (SPMSMs) that were both electrically connected on three winding phases and mechanically connected on one shaft

According to authors Yaman B. Zbede, Shady M. Gadoue, and David J. Atkinson, presented in published paper of **“Model Predictive MRAS Estimator for Sensorless Induction Motor Drives”** described that introduction of the proposed estimator is based on the finite control set model predictive control (FCS-MPC) principle. The rotor position is calculated using a search-based optimization algorithm which ensures a minimum speed tuning error signal at each sampling period. This eliminates the need for a proportional integral (PI) controller which is conventionally employed in the adaptation mechanism of MRAS estimators.

According to authors Sunku Kwon, Student Member, IEEE, and Jung-Ik Ha, Fellow, IEEE, presented in published paper of **“Fault-Tolerant Operation under Single-Phase Open in Mono Inverter Dual Parallel SMPMSM with Single Shaft”** described that introduction of fault-tolerant operation for dual three-phase surface-mounted permanent magnet machines (SPMSMs) that were both electrically connected on three winding phases and mechanically connected on one shaft. authors

According to the authors Enrique Ledezma, Brendan McGrath, Alfredo Muñoz, Member, IEEE, and Thomas A. Lipo, Fellow, IEEE, presented in published paper of **“Dual AC-Drive System With a Reduced Switch Count”** described that introduction of A dual current-regulated pulsewidth-modulated voltage-source inverter based on multiple two-phase PWM inverters, also called a B4 topology, requiring a dual ac-drive system with reduced switch count is proposed. The drive utilizes a total of only eight switches to produce two sets of three-phase or two-phase sinusoidal output currents that can be employed to feed three-phase or two-phase induction motors

According to authors Philippe Delarue, Alain Bouscayrol, Member, IEEE, and Eric Semail, Member, IEEE, presented in published paper of **“Generic Control Method of Multileg Voltage-Source-Converters for Fast Practical Implementation”** described that introduction of A generic and simple control method is suggested for any multileg voltage-source-converter. A specific coding yields an inversion table allowing a fast practical implementation. Phase-to-phase voltage references have to be defined for such a table. This original control strategy is validated by experimental results for two-leg, three-leg, four-leg, and five-leg structures supplying balanced and unbalanced multiphase loads.

According to the authors Young-Seol Lim, Student Member, IEEE, June-Seok Lee, Member, IEEE, and Kyo-Beum Lee, Senior Member, IEEE, presented in published paper of **“Advanced Speed Control for Five-Leg Inverter Driving a Dual-Induction Motor System”** described that introduction of advanced speed control for a five-leg voltage source inverter (FLVSI) Stability analysis of the two controllers under advanced speed control is implemented, and the whole performance of the advanced speed control for FLVSI fed the dual-motor drive system

According to the authors Chee Shen Lim, Student Member, IEEE, Nasrudin Abd. Rahim, Senior Member, IEEE, Wooi Ping Hew, and Emil Levi, Fellow, IEEE, presented in published paper of **“Model Predictive Control of a Two-Motor Drive With Five-Leg-Inverter Supply”** described that introduction of Model predictive control (MPC) for a two-motor drive, supplied from a five-leg inverter, is presented in this paper. As an alternative to existing methods, use of MPC in multimachine drives has the advantages of independent fast current control of the machines, elimination of the closed-loop system’s cascaded structure, and a reduced number of microcontrollers. A vector control algorithm is required, necessitating state-space modeling, with each machine’s direct- and quadrature-axis currents chosen as state variables.

According to the authors Saverio Bolognani, Student Member, IEEE, Silverio Bolognani, Member, IEEE, Luca Peretti, Student Member, IEEE, and Mauro Zigliotto, Member, IEEE, presented in published paper of **“Design and Implementation of Model Predictive Control for Electrical Motor Drives”** described that introduction of Speed and current controllers are combined together, including all of the state variables of the system, instead of keeping the conventional cascade structure. In this way, the controller enforces both the current and the voltage limits. Both simulation and experimental results point out the validity of the design procedure and the potentials of the MPC in the electrical drive field.

According to the authors Hernán Miranda, Student Member, IEEE, Patricio Cortés, Member, IEEE, Juan I. Yuz, Member, IEEE, and José Rodríguez, Senior Member, IEEE, presented in published paper of **“Predictive Torque**



**Control of Induction Machines Based on State-Space Models**” described that introduction of predictive control algorithm that uses a state-space model. Based on classical control theory, an exact discrete-time model of an induction machine with time-varying components is developed improving the accuracy of state prediction.

According to the authors Samir Kouro, Member, IEEE, Patricio Cortés, Member, IEEE, René Vargas, Student Member, IEEE, Ulrich Ammann, Member, IEEE, and José Rodríguez, Senior Member, IEEE, presented in published paper of “**Model Predictive Control—A Simple and Powerful Method to Control Power Converters**” described that introduction of Finite Control Set Model Predictive Control (FCS-MPC) applied to power converters. Several key aspects related to this methodology are, in depth, presented and compared with traditional power converter control techniques, such as linear controllers with pulse width-modulation-based methods.

### Problem Statement

Basically three phase induction motor is run on three leg inverter. So that to run two induction motor of three phase, six leg inverter is required. Therefore switching losses increases and cost of model also get increases.

### How to overcome

To overcome this problem, instead of six leg inverter, we used five leg inverter. Means to make one common phase from six phase motor. So that there are five phases which can run on five leg inverter. The one leg from six phase induction motor is treated as shared leg.

## III. METHODOLOGY AND WORKING

In this, Priority Based MPC (PMPC) method is used for both

1. Low Computational cost.
2. Small Current Ripples.

Following are the steps to run this model, are describe shortly.

1. Motor Polarization
2. Two-Stage Optimization
3. Cost Function Evaluation
4. Zero Voltage Vector Selection in PMPC Method

### Motor Polarization

To identify HM & LM conduction of motor Prioritization is takes place for two stage optimizations. In the PMPC method, HM is improved by entire candidate voltage vector but LM is less improved as compare to HM Because of limited candidate voltage vector. This means Prioritization should not biased to one side, therefore for the optimization of both the induction motor together each induction motor should be selected as HM [1].

### Two-Stage Optimization

Two stage optimization is important part of PMPC method. There are two different optimizations for HM and LM Individually. Each optimization consists of candidate voltage vector selections, current predictions and cost minimization. Symbol of voltage vector are  $V_{1,x}$ ,  $V_{2,x}$  For HM and LM ( $V_{hmc}$ ) and LM ( $V_{lmc}$ ) should be selected.

Optimal switching state selection to the state of  $Sc_p$  (Switching of leg C) and Optimization is conducted by priority signal ( $F_{pri}$ ) there is case 1 & Case 2 both occur. When priority signal is set as 1 with the result that Induction motor 1 is selected as HM. Therefore IM1 is optimize before IM2 [9].

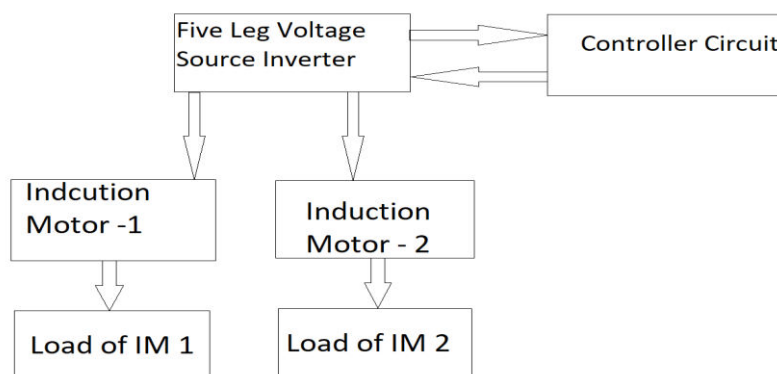


FIGURE 1: Block Diagram

**Cost Function Evaluation**

To find future voltage vector for IM minimum cost function should be evaluated. In PMPC, as optimization is sequentially address depending on motor optimization. There are two different cost minimization parts for HM and LM. In first optimization, the cost of function of HM (G<sub>hm</sub>) is evaluated. In the second optimization cost function for LM (G<sub>lm</sub>) is Minimize [9] , [10], [12] .

**Zero Voltage Vector Selection in PMPC Method**

There are two zero voltage vectors ( $V_m 0[000]$  or  $V_m,7[111]$ ). In the PMPC method and they have same costs. In first optimization stage if zero voltage vector have minimum cost, a selection criterion between  $V_m, 0 [000]$  and  $V_m, 7 [111]$  is required. In order to reduce switching losses and electromagnetic interference zero voltage vector with minimum switching changes from present  $v_0$ ltag voltage vector is selected as a future voltage vector For HM in first optimization [1], [9].

If three phase induction motor is used then two one, three leg inverters are required, in this there is five leg inverter is for two induction motor, one leg of inverter is treated as shared leg. By this switch can reduces MPC based gate pulse generation program block, which will generate gate pulse for five arms to control the speed if Induction motor, PI Controller Park and plug transformation [1].

**IV. SIMULATION AND RESULT**

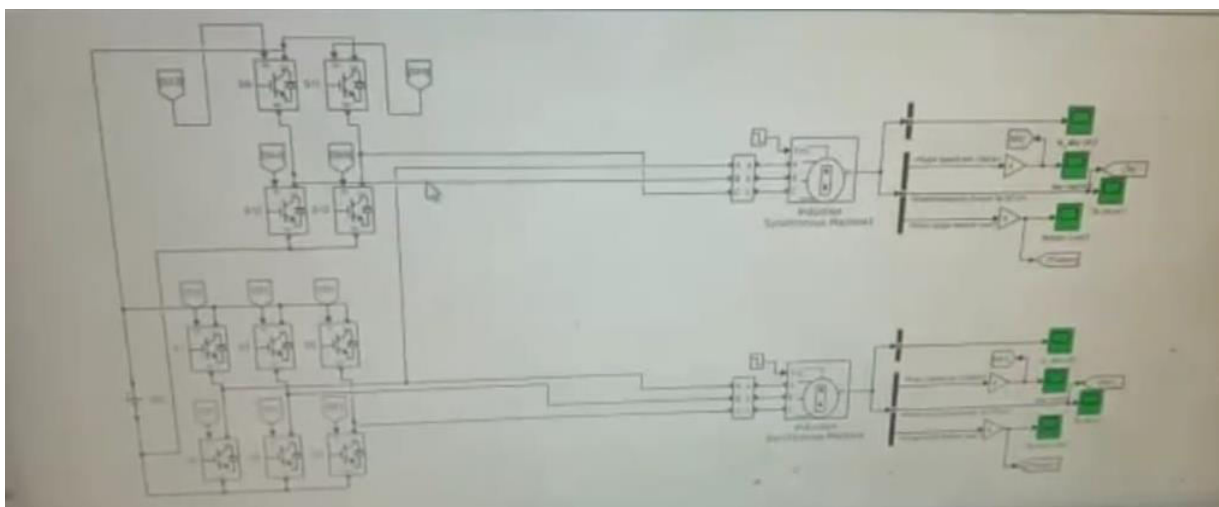


FIGURE 2: Simulation Diagram of two three phase IM with 5 leg inverter



In Above figure shows the simulation of two three phase Induction Motor with common Five leg inverter with the priority level shifting, scopes are connected for showing the results of simulation.

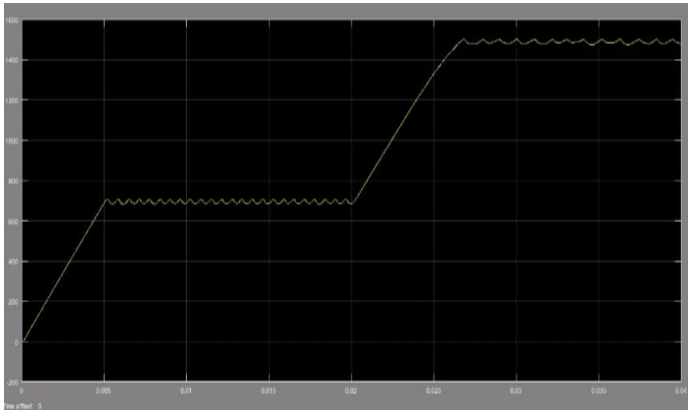


FIGURE 3: Result Graph of Speed

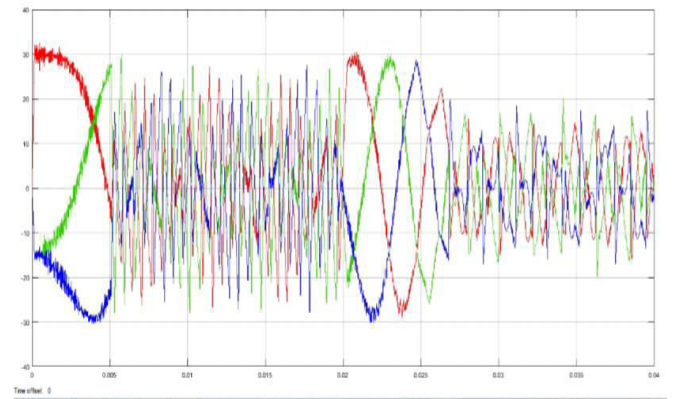


FIGURE 4: Motor Current

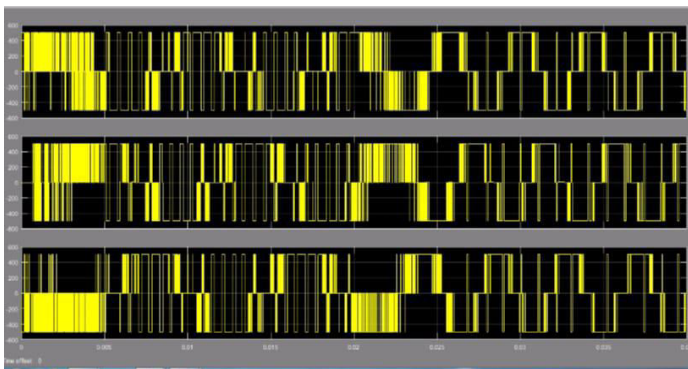


FIGURE 5: Result Motor Voltage

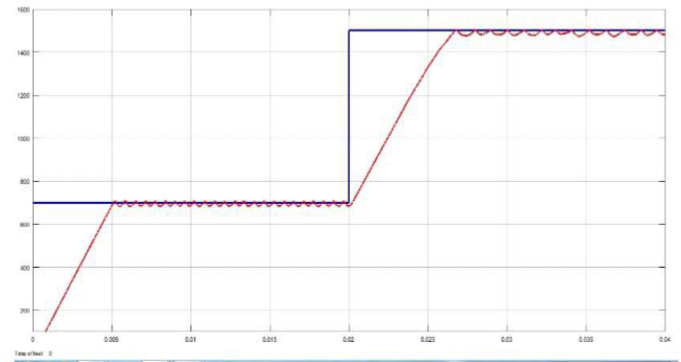


FIGURE 6: Actual speed VS getted speed

## V. CONCLUSION

In this paper PMPC method to drive dual induction motors using the FLVSI. The conventional MPC methods for the FLVSI, such as the FSMPC and A-MPC methods, have difficulty achieving low current ripples and computation burden simultaneously. However, the proposed PMPC method can attain both objectives. In the PMPC method, optimal voltage vectors for each motor are selected in order depending on the motor prioritization. For this property, the PMPC method has similar current ripples with those of the FSMPC method and also less computation burden than the A-MPC methods. The feasibility of the PMPC method was demonstrated and analyzed by simulations and experiments. In addition, the current ripples and computation time of the PMPC method and the conventional MPC methods were compared. Consequently, it was validated that the PMPC method has low current ripples comparable with those of the FSMPC method as well as a considerably reduced computation burden relative to that of the A-MPC methods.

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