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Performance Comparison of Multilevel Inverter Topologies for Closed Loop v/f Controlled Induction Motor Drive

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Abstract

This work focuses on investigating the closed loop model of Multilevel inverter fed Induction Motor Drive with constant V/f method. Multi level inverter generates stepped sinusoidal waveforms of lower harmonics with increasing levels. Cascaded MLI of 5 level and conventional VSI are synthesized using sinusoidal pulse width modulation (SPWM). The multi level inverter output so developed assuring the least THD is then passed through a filter to get a better sinusoid output. The filtered output is then fed to the induction motor, mathematically modeled using procedural sequence of equations. Induction motor speed control is employed by regulating the slip speed maintaining constant V/f. PI controller is implemented to ensure the motor speed at its reference speed. Closed loop scheme is tested for various reference speed and disturbances in dynamic load and speed. Comparative evaluation of transient and steady state performance characteristics, system efficiency and cost effectiveness is analyzed for closed loop MLI as well as VSI fed induction motor drive. MATLAB/SIMULINK setup, an effective tool for simulation is used for validating the results.

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Keywords: Cascaded H-Bridge Multilevel Inverter(CHBMLI); Induction motor;V/f control.

1. Introduction

Electrical drive is simply an electromechanical configuration bonded by energy synthesis for motion control[1].Drives have turned to be dominant player in the industrial sector and guarantee a path for wide explorations. Researchers nowadays emphasize the enhancement of sophisticated electric drive [2].Induction motor (IM) draws major attention for innovative progress in drives. In induction motor draws major attention for innovative progress in drives. In induction motors, stiff speed prevails with regard to load variances. A motor operates in extreme ranges with wide differential speed in absence of a drive. But speed regulation is ensured with drive, minimizing the extreme level operation and thus paves the way for necessity of drives. Induction motor follows various control schemes classified as; a) Scalar control b) Vector control

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Scalar controlled type drives being easier to build, are widely preferred in industries [2],[3],[4].Scalar control differs from vector control in its procedure of monitoring variables. Scalar control as its name reveals considers the magnitude change in variables and neglects the machine coupling effect. Vector/field oriented control is the scheme in which magnitude in addition to the alignment of phase needs to be controlled. Few scalar control options are Stator voltage control, Stator frequency control, Stator voltage and frequency control, Stator current control, Stator rotor-resistance control, and Slip energy recovery control[2],[3],[4],[5],[6].

Out of these schemes, variable voltage and frequency (V/f) is the easily implementable, simpler and popular scheme in industries. Any scheme can be in two modes either in open loop or closed loop. Closed loop outwits the open loop in the sense that closed loop yields precise control when load is applied. Supply configuration used for induction motor drive is the dc-ac converter. Voltage source inverter (VSI) and Multi-level inverter (MLI) are the major power circuits for induction motors. Any machine exhibits efficient performance with harmonic free sinusoidal supply. Three-phase VSI with six power switches, connected to DC input synthesize quite quasi-square waved line voltage inclusive of harmonics. MLI is the topology rooted as an initiative harmonic minimization, generating a stepped sinusoid. Let the levels in MLI numbered as ‘m’and harmonics be ‘h’, they are related as inversely proportional. The rise in ‘m’ reflects the output to intend better sinusoidal profile. MLIs are categorized as Cascaded H-Bridge, Diode Clamped, and Flying Capacitor. The proposed work is targeting on feasible electric drive suitable for variable speed applications in industries.

2. Cascade MLI fed Induction Motor

Three phase IM requires 3 phase ac supply in an attempt of limiting starter current and is powered using simplified cascaded MLI .It requires dc-inputs and transform it to alternating output wave with the triggering role of power-electronic switches. Mostly IGBTs occupy dominant choice compared to rest switches. For five level CHBMLI, five steps contribute to the output wave-shape. With V_{dc} as inputs, then the outputs take levels, $+2V_{dc}$, $+V_{dc}$, 0, $-V_{dc}$, $-2V_{dc}$. Fig.1 shows 5 level simple H-bridge cascaded MLI.

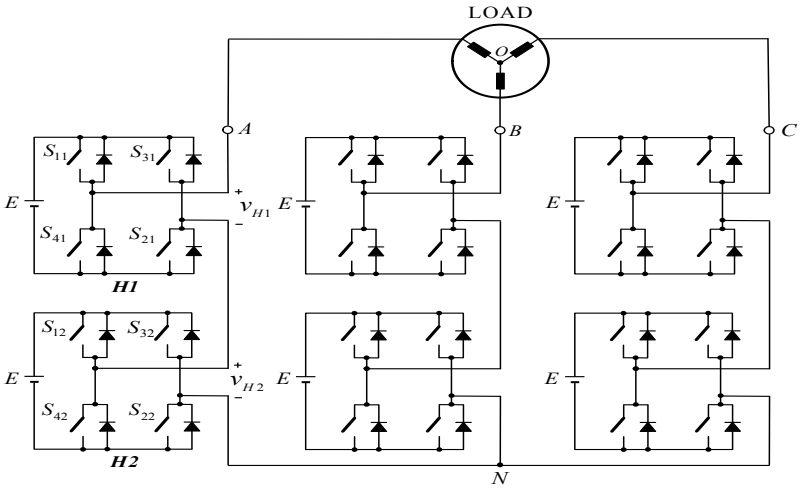

Fig. 1. Five level cascaded MLI

In brief, the MLI output levels , m= (2*i) + 1, where i = dc inputs. PWM leads the vital role in circuit action by firing the respective switches (IGBTs) at the exact instants to output the proper reaction. Various techniques exist and few are; Space vector, selective harmonic-elimination involving complex computations, Carrier PWMs etc. One adopts Carrier-based PWM (CB-PWM), if compactness is targeted. Reference sine and triangular carrier are compared to