A New Approach for BLDC Motor Performance with Diode Clamped and Cascaded H-Bridge Multilevel Inverter

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ABSTRACT: Brushless direct current (BLDC) motors have characteristics of high reliability, simple frame, and small friction. By comparing with PMSM, BLDC motor has the advantages of high speed adjusting performance and power density. BLDC motor widely used for industrial applications. It has constant torque under ideal conditions but practical case torque ripple appeared due to the freewheeling of inactive phases and commutation failure. Torque ripple affects the smoothness of variable speed control. Various control techniques and methods are used to reduce the torque ripple. In this paper analyze the performance of BLDC motor with cascaded H-Bridge multilevel inverter and diode clamped multilevel inverter. This has been simulated using MATLAB simulation software and the torque ripple is calculated.

KEYWORDS- Brushless DC Motor (BLDC), Diode Clamped Multilevel Inverter, Cascaded H-Bridge Multilevel Inverter, Torque Ripple, Adaptive Neuro Fuzzy Inference System (ANFIS), Sinusoidal Pulse Width Modulation (SPWM)

I. INTRODUCTION

Grid-related photovoltaic energy conversion systems had been growing in current years because of the non-stop deduction of the PV modules expenses and the increase of the conversion performance as well as the upward thrust in costs of fossil fuels. This fashion is predicted to continue within the coming years [1], [2]. As the electricity degree of the PV systems increases and the grid connections are also mounted at medium voltages, the device can enjoy the usage of a multilevel converter because it represents a green solution for high electricity and medium voltage applications. It lets in operating at voltage ranges better than the bounds of the character strength switches in the conversion manner. Moreover, it may generate supercurrents and voltages with decreased commonplace mode voltages and smaller voltage adjustments as properly as the era of lower EMI with reduced switching frequency and with higher performance [3].

The cascaded H-Bridge (CHB) multi-level converter topology has been broadly proposed for PV conversion programs [1], [2], [4], [5], [7] - [14] as it gives a modular answer by using accumulating huge numbers of PV panels as an isolated DC assets which permit generating a massive some of the voltage tiers in the output. These mixtures reap a character maximum power point tracking (MPPT) through DC-DC converters enhancing the conversion efficiency of the gadget. In a conventional PV system, both the dc current and voltage sensors are required by using the Maximum Power Point Tracking (MPPT) algorithm. Several unmarried voltage sensor PV structures were proposed within the literature. In [18], the dc voltage sensor become removed and the MPPT was implemented the use of the dc-dc converter's obligation cycle and the dc In [19], the MPPT changed into applied via simplest sensing the dc voltage. The exchange of the energy added by the inverter changed into inferred from the manipulate signals. Tracking the real maximum electricity point of a PV array the usage of most effective the voltage sensor become carried out by connecting a capacitive load to it in [20], [21]. However, a particular form of converter became required to put into effect the proposed technique. In precise, none of these researchers have been applied for a CHB-MC based PV system and in none of them were both the DC current and the dc voltage sensors eliminated. In traditional CHB-MC primarily based PV systems the dc modern-day sensors are required by using the MPPT module and the dc voltage sensors are required for the capacitors' voltage manage gadget and the Pulse Width Modulation (PWM) generator. Hence, in better degree converters, many remoted dc sensors are required, which will increase the system value and complexity. The dc voltage sensors

removal in CHB-MCs turned into addressed in a few papers, however handiest for STATCOMs.

II. PROPOSED CONTROL SCHEME

BLDC Motor actual speed and reference speed is compared to provide input (error signal –difference between both speeds) to controller. PI controller Kp is determines current error and Ki determines future error. PI controller output and measured Back EMF is multiplied to provide the reference signal for the sinusoidal pulse width modulation. PI controller's trained data is used for ANFIS training. Sinusoidal PWM is used to shift the lower order harmonics to higher order harmonics. Because, lower order harmonics frequency near to the fundamental frequency so it leads difficulty for filtering and lower order harmonics requires high pass filter to increase filter cost. ANFIS is trained based on the previously simulated PI controller data's. PI controller tuning is difficult and it requires an experts to tune and it have slow response. But ANFIS have the advantage of both Fuzzy logic and Artificial Neural Network.

BLDC motor rotor part is having permanent magnet and stator part having three phase winding. So it has less inertia and friction. But the speed control is difficult due to the absence of field winding. The Brushless DC motors have many advantages like better mechanical characteristics, high efficiency, high dynamic response, small size and easy construction [9]. In the last years, brushed dc motors and induction motors for small applications can be replaced by brushless dc motors.
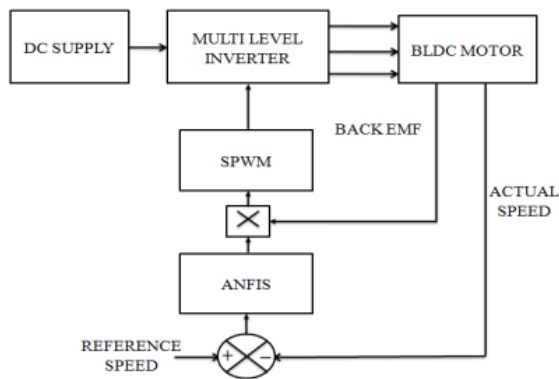

Figure 1: Block diagram of BLDC drive system

A). Multilevel Inverter:

Diode clamped Multilevel Inverter: A three phase five level diode clamped multilevel inverter topology is shown in figure 2. Three phase inverter output voltage shares common dc bus voltage and it is divided for five levels using dc capacitors. In this multi level inverter have three legs. Each leg has switches, clamping diodes and freewheeling diodes for each leg have upper and lower legs. Voltage across the each capacitor is and clamping diodes are used to limit voltage stress across the switching devices.

B). Cascaded H-Bridge Multilevel Inverter:

The cascaded H-bridge inverter dc source on the dc side, which can be obtained from batteries, fuel cells, or ultra capacitors, and series-connected on the ac side. The advantage of this topology is that the modulation, control, and protection requirements of each bridge are modular.
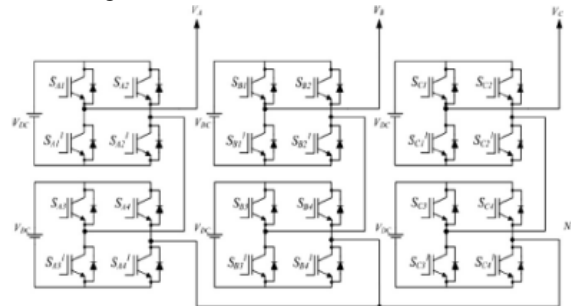

Figure 2: Three phase five level Cascaded H-Bridge multilevel inverter topology

It should be pointed out that, unlike the diode-clamped and flying-capacitor topologies, isolated dc sources are required for each cell in each phase. Number of levels can be increased by adding the bridges series. Switches in same leg does not conduct at same time because of avoid the short circuit.

C). Adaptive Neuro Fuzzy inference system training:

In the five level diode clamped multi level inverter fed BLDC have one PI controller. ANFIS controllers are derived from the PI controlled system. For ANFIS training first step are get data (PI controller input and output) from workspace and select that data's from workspace in and out. The out data is copy and paste to in column of workspace. After that

to load the data's from workspace and select grid partition and generate FIS option for give the number of rules. Member functions are 15 in this paper, input is 1 and output is 1. To train until reach error is zero and epochs give nearly 100000 (i.e., Based on the error level).

III. SIMULATION RESULTS

Figure 3 shows the simulation diagram of five level diode clamped multilevel inverter fed BLDC motor. The motor output speed and reference speed can be compared and that error signal given input for ANFIS. ANFIS output is multiplied with the Back EMF. This multiplied signal is given to reference signal of Sinusoidal pulse width modulation, based on the reference signal gate pulses generated and given to Diode clamped multilevel inverter. So the rotor position is sensed by sensor less technique that is Back EMF is measured to detect rotor position.
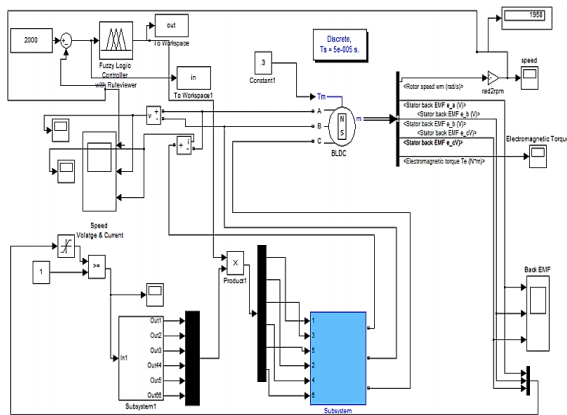

Figure 3: Simulation diagram for five level diode clamped multilevel inverter fed BLDC motor

Figure 4 shows the cascaded H-Bridge multilevel inverter fed BLDC motor with ANFIS. This is done by using previously simulated PI controller data's. Train Adaptive Neuro Fuzzy Interferance System several times to get better result, that is error is zero. ANFIS simulation file is generated at the end of training. PI controller is replaced by ANFIS.
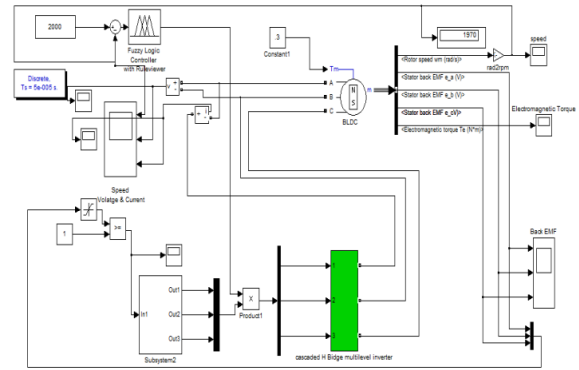

Figure 4: Simulation diagram for five level cascaded H-Bridge multilevel inverter fed BLDC motor.

Figure 5 shows the speed of BLDC motor, Speed of diode clamped MLI fed BLDC motor is have more deviation compare to cascaded H-Bridge MLI fed BLDC motor output speed, here set speed is 2000rpm.
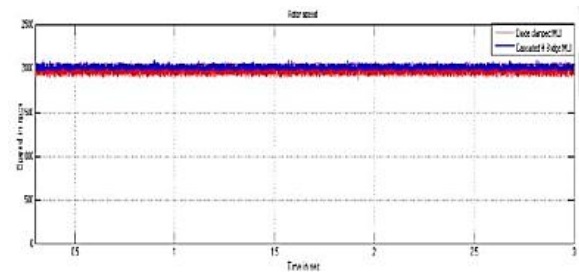

Figure 5: Output Speed

Torque ripple produced in BLDC motor due to freewheeling of inactive phases and commutation failure. It is affect the variable speed control of system and smoothness.Torque ripple can be minimized by two techniques, they are improve motor design and motor control schems. Torque ripple is defined as percentage of difference between maximum torque(t_{max}) and minimum torque (t_{min}) compared to the average torque (t_{avg}). Equation (1) is used for determine torque ripple.

$$\frac{T_{max} - T_{min}}{T_{avg}} * 100\% \ \dots\dots\dots\dots\dots\ (1)$$
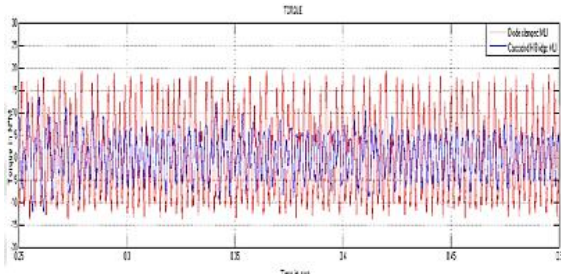
Figure 6: Electromagnetic Torque

IV. CONCLUSION

In this paper five level diode clamped multilevel inverter and cascaded H-Bridge multi level inverter fed BLDC motor presented and analyzed the torque ripple, Speed. From the simulation BLDC motor results are analyzed and torque ripple was calculated for both diode clamped and cascaded H-Bridge multilevel inverter. From the simulation results proved that the torque ripple is reduced in cascaded H-Bridge multilevel inverter is better than diode clamped multilevel inverter. Also the speed controlled by cascaded H-Bridge multi level inverter is better than diode clamped multilevel inverter.

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