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Hybrid Cascaded H-bridges Multilevel Motor Drive Control for Electric Vehicles

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Abstract: This document presents a multi-story cascading H-bridge multi-stroke electric-hybrid motor drive control scheme where only one DC source and capacitors to other DC sources can be applied to each stroke of a three phase cascaded multi-level converter. Each phase of a cascaded, three-phase, multi-level converter traditionally requires n DC sources for 2n + 1 power output levels. The present document proposes a scheme which enables a single DC source as the first DC source to be used, whereas the remaining n-1 DC sources are condensers. It is shown to be possible to keep balance between the DC voltage levels of condensers at the same time with a simple 7-stage output voltage control, to eliminate specified low order non-tripple harmonics and produce almost sinusoidal 3-stage output voltage. Therefore, this system enables higher voltages at higher speeds (if necessary) with a low switching frequency procedure, with low switching frequency and high conversion efficiencies inherent in the drive application. This control system is particularly suitable for motor driving applications of fuel cells and hybrid applications of motor vehicles for electric vehicles.

Keywords: Hybrid cascaded H-bridge multilevel converter, DC voltage balance control, multilevel motor drive, electric/hybrid electric vehicle application.

I. INTRODUCTION

Due to its low electromagnetic interference (EMI) and high efficiency, the multi-levee converter is a promising high power electronic topology for high power motor drive applications. The cascaded multi-level conversion unit with separate DC sources can fit many requirements of all-electric trucks as it can generate an almost sinusoidal power waveform using the onboard batteries or fuel cells[1]-[3]. Each stage of a cascading multi-level converter traditionally requires 2n + 1 DC sources[1]-[3]. It's difficult to get several separate DC sources for many applications and too many DC sources need a lot of long cables and could cause the DC sources to become voltage imbalance.

In this paper, a scheme is being proposed to reduce the amount of DC sources required when a cascading H-bridge converter is used on a motor drive that allows the use of a single DC source (such as a battery or fuel cell) as a first DC source with the remaining Hbridges n−1 DC sources as a condenser. The control objective here is to keep each condenser balance of the DC voltage level while simultaneously generating a three-phase almost sinusoidal output voltage with a low switching frequency control procedure. The system thus allows high voltages to be produced at higher speeds (where necessary) using a low switching frequency with lower switching losses and high conversion efficiency. The hybrid multi-level motor drive in this paper is known as this multi-level converter motor drive. Two to three H-bridges for each phase represent a good balance between performance and cost in electric / hybrid motor vehicle applications.

II. LITERATURE REVIEW

A. Introduction

This chapter briefly examines the development of a multi-level inverter control (SHE) problem of non-linear transcendental selective Harmonic Elimination with the objective of controling the chosen multilevel inverter configuration for the complete range of the modulation index of 0 to 1 with less percent THD that meets the guidelines and l of IEEE 519-1992 Commercially existing multi-level inverter topologies and the multi-level inverter modulation strategy will be reviewed briefly. It also looked at the progress of the research on different methods for the resolution of non-linear transcendental SHE problems. The objective of research, research methodology and the organization of theses are also presented in this chapter.

B. A Brief Review Of Multilevel Inverter Topologies

Now, modern industries have met megawatt power requirements. High power medium voltage drives, in particular, require power in the megawatt range and are usually connected to a network with medium voltage. The connection of a single, medium voltage (2.3kV, 3.3kV, 4.16kV or 6.9 kV) power halver can be difficult. For this reason, multilevel inverters have proven to be a cost effective solution for high-voltage, power and motor drive issues.

The multi-level converter is not only a cost-effective solution, but allows the application of low energy into renewables as well and provides higher voltage and power ratings. This converter is suitable for high voltage and high-performance applications because they have the ability to synthesize higher voltages with a limited maximum device rate, lower harmonic distortion, produce less common-mode voltage (CM).

The inverters currently use multi-level in a wide number of applications, including HVDC distribution systems, medium-tension engines, Flexible AC Transmission System (FACTS), Var compensation and stability enhancement traction systems, active filters, chemical, LNG, marine propulsion systems, powertrains (EVS)[35]. Multilevel inverters are currently widely used in various applications.

The power range of the two-level inverter has a very important and obvious limitation. However, the concept of multi-level converters in 1975 can overcome this problem. The multilevel concept began with the third-level converter, which is often known as the NPC. The word "converter" refers to the power flow, both in terms of "rectifier" (ac to dc), and in terms of "inverter" (dc to ac). The term "multi-level inverter" means the use of an inverting multi-level converter.

The development of different inverter topologies was followed by the percent THD to comply with IEEE 519-1992 harmonic instructions for the confrontation of challenges, such as high dv / dt voltage-reduction effect in engine power voltage on waveform, high electromagnetic interference (EMI), high common mode voltages and requirements for synthesizing increased voltations for advanced industrial applications. The commercially available topologies for inverters are the inverter topologies Neutral Point Slash (NPC), Flight Capacitor (FC) and Cascaded H-Bridge (CHB), and will be reviewed shortly.

III. MODULATION CONTROL

Traditional PWM control techniques and PWM space vector methods are generally used for multi-level modulation control converters. Due to the large switching frequency [6]-[15], the disadvantage of the standard PWM method are loss of power. For these reasons, we have proposed low-power frequency control methods for motor drive applications, such as the basic frequency approach [15] and the active harmonic disposal method. The fundamental frequency switching angles may then be used in the hybrid hybrid multilevel control motor driving if the nominal capacitor voltage is selected as Vdc/2. This is the simplest way of controlling the hybrid multilevel drive proposed. The proposed hybrid cascade converter motor drive is also an effective modulation control method.

A. 7-Level Equal Step Output Voltage Switching Control. The Fourier Series Expansion of the 7-level Equal Step Output Voltage Waveform is

$$V(\omega t) = \sum_{n=1,3,5\Lambda}^{\infty} \frac{4V_{dc}}{n\pi}(\cos(n\theta_1)+\cos(n\theta_2)+\cos(n\theta_3))\sin(n\omega t)$$

where n is the harmonic number of the output voltage of the multilevel converter. Given a desired fundamental voltage V1, one wants to determine the switching angles θ1, θ2, θ3 so that V(ωt) = V1sin(ωt), and specific higher harmonics of V(nωt) are eliminated [18]-[20]. The triplenic harmonics in each phase do not need to be canceled for 3-phase motor drive applications, as these cancel automatically with line-to-line voltages. The purpose of this paper is to eliminate harmonics 5th and 7th. The solution to the following equations can be formulated mathematically:

$$\cos(\theta_1)+\cos(\theta_2)+\cos(\theta_3)=m$$

$$\cos(5\theta_1)+\cos(5\theta_2)+\cos(5\theta_3)=0$$

$$\cos(7\theta_1)+\cos(7\theta_2)+\cos(7\theta_3)=0$$

This is a system of three transcendental equations in the three unknowns θ1, θ2 and θ3. There are many ways one can solve for the angles

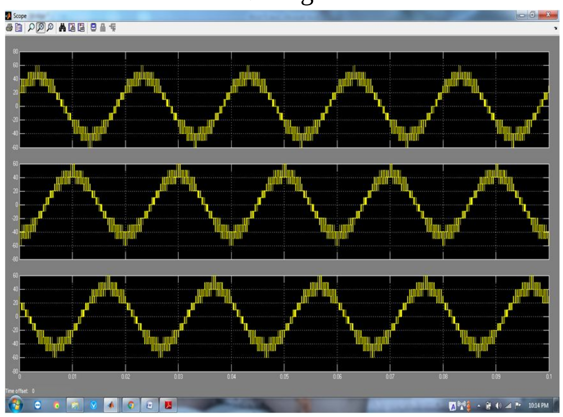
B. Hybrid Electric Vehicle Application Considerations

An electric / hybrid vehicle is a possible application for the cascaded hybrid multi-level engine drive. Hybrid / electric vehicles use electric motor batteries. Continuously, an electric / hybrid electric cars three-stage full bridge PWM converter is used. The battery voltages limit the instantaneous output power and a high-power DCDC boost converter must use the braking power to charge the batteries. There are two advantages over this traditional topology to the proposed hybrid cascaded H-bridge motor. The proposed multi-level hybrid engine drive can produce inherently a greater output voltage than the standard tri-level engine drive. The hybrid multi-level, multi-level cascaded engine can also be used to absorb low-speed braking energy because one or more condensers can be charged on the basis of charging voltage without a DCDC boost converter that has a high power.

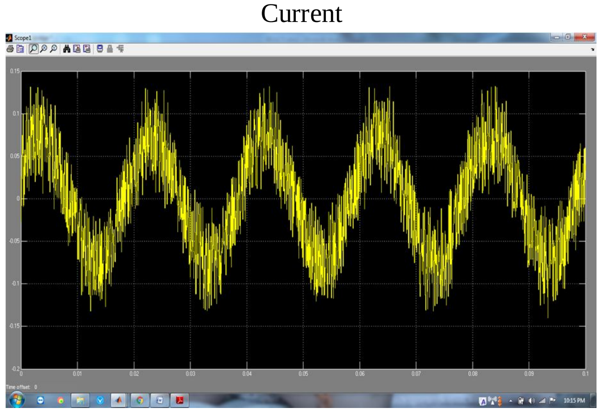
IV. SIMULATION RESULTS

A. Simulation Results for 30Hz

Voltage

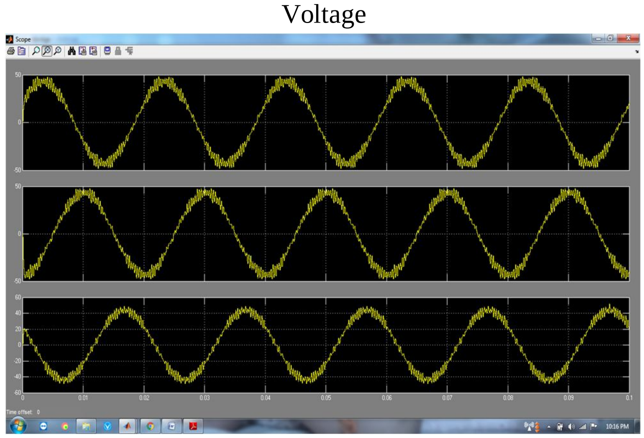


Current



B. Simulation Results for 60Hz

Voltage



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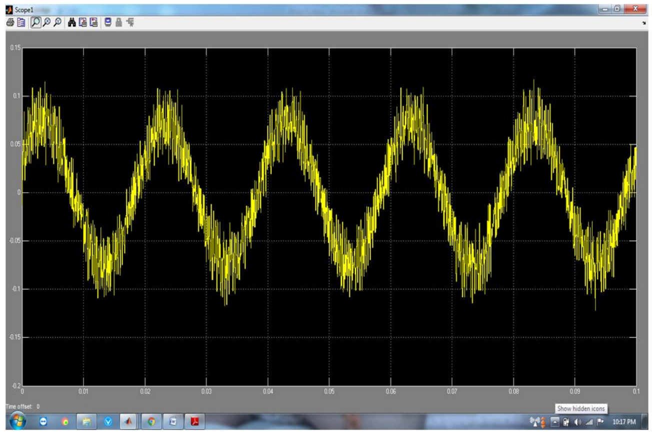

V. CONCLUSIONS

This paper developed a new multi-level motor control system for hybrid cascaded H-Bridges, which only required one power source for each phase. The motor drive has been equally controlled using a 7-level output voltage switching method. From the computational results and experimental Hethod and eliminate the low-order harmonics.

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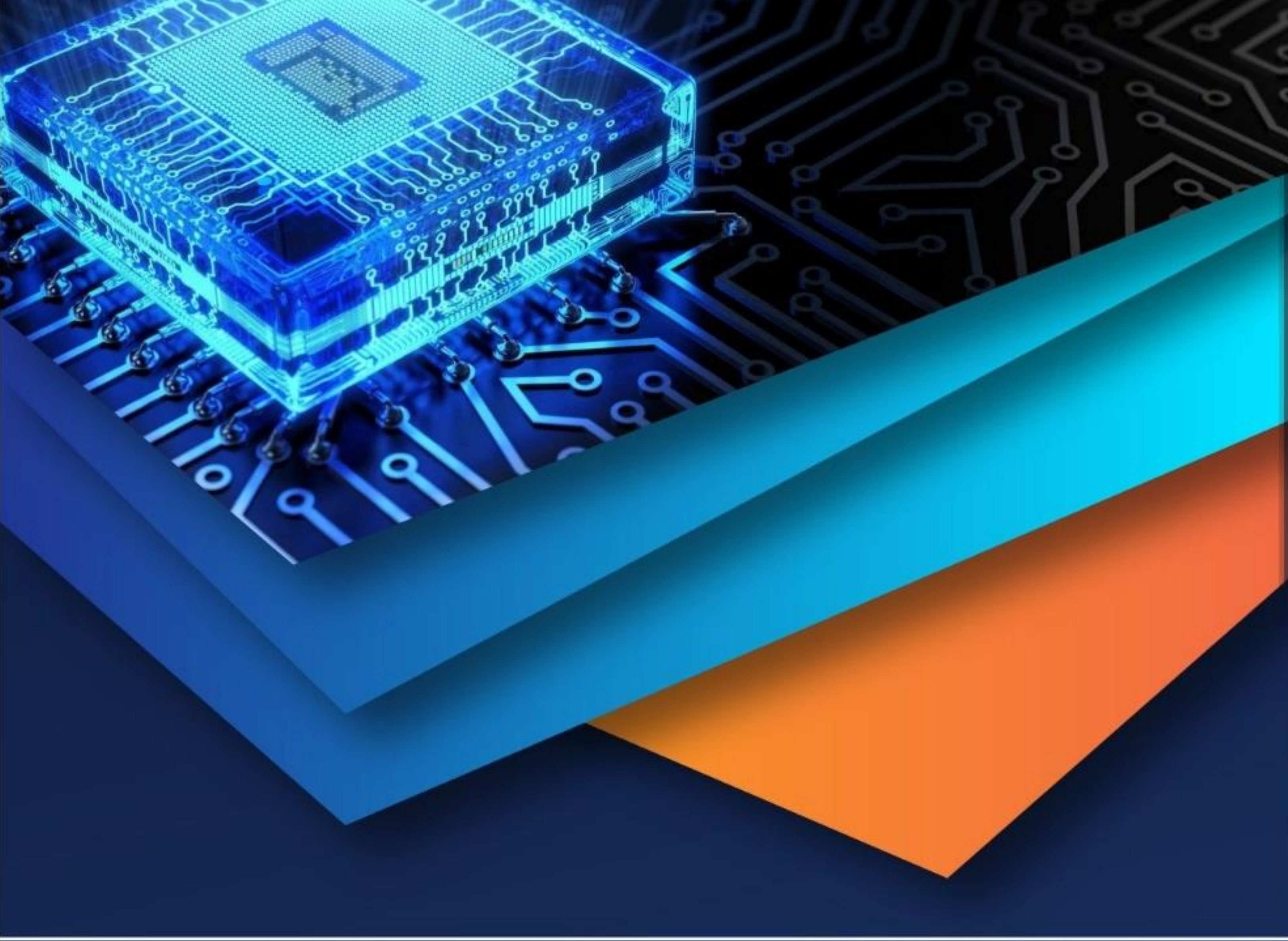

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