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A Simplified Filter Topology for Compensating Common Mode Voltage and Electromagnetic Interference in Induction Motor Drives

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Abstract

Recently the utilization of electric vehicle technology increasing drastically, because of environmental changes arises throughout the globe. Based on these issues, this paper focuses on the drive used in the electric vehicle with more economically. In general electric vehicles the induction motor drives are used, because they have great features, such as high starting torque and high efficiency. The motor drive is driven by high switching frequency PWM inverter supplied through a DC supply, since high switching frequency common mode (CM) voltage generated at the stator input motor terminals. This will create a shaft voltage through the motor air gap and raises the motor bearing current. This causes the premature damage to the motor reliability and lifetime. To compensate this problem an advanced active filter is designed, which will suppress the common mode voltage. And also analyze the impact of electromagnetic interference (EMI) on drive under the test (DUT). The above system will initially be executed in the electrical software tools like MATLAB/SIMULATION for confirmation of the results, suitable for electric vehicle applications, especially for induction motor drives.

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Keywords: *Common mode (CM) voltage, Shunt active filter, Electromagnetic Interference (EMI), Induction Motor drive.*

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1. Introduction

In the recent applications of electrical vehicles, the high-quality output is achieved through the pulse width modulation (PWM) IGBT switches. Due to high switching frequency at the inverter output terminals, it generates the common-mode voltages at drive input side. Therefore common mode voltage produces shaft voltage resulting in the production of bearing currents through stray capacitances. The magnitude of the shaft voltage and bearing current influences the Electromagnetic Interference (EMI) problem. It also leads to severe damage to the insulation of the motor, such as the lifetime and the reliability of the motor [1].

Nomenclature

α	Controlled rectifier firing angle
CM	Common Mode
C	Star connected capacitor unit
C^I	Voltage divider capacitor
C_d	DC-Link Capacitor
f	Frequency of the rectified voltage
fs	Inverter switching frequency
IGBT	Integrated gate bipolar transistor
L_1	Primary Inductance
L_2	Secondary Inductance
T_1	Toroidal transformer primary turns
T_2	Toroidal transformer primary turns
V_{sh}	Shaft voltage
V_{cm}	Common mode voltage

Some of the previous literatures expressed that, suppression of the common mode voltage in the induction motor drives fed by pulse width modulation inverters with high voltage DC supply is one of the most familiar methodology [2-4]. They have proposed the common mode active filters to mitigate the common mode voltage at the input side of the motor terminals. Generally two kinds of methodologies are proposed to synthesize the common mode voltage, one of them is the passive circuitry [5], it consists of passive resistors, inductors, capacitors and common mode chokes. The values of those parameters depend on the length of the cable from inverter and motor [6]. The second methodology used to mitigate common mode voltage on the inverter fed induction motor drive is with an active circuitry. This is one of the most effective processes used in the industrial drives in the last five years. Generally, it eliminates the mirror image of common mode voltage, i.e. shaft voltage and the bearing currents [7-8]. This active circuit canceller contains different parts for detection and reinjection of the voltage in the line. This detection circuit consisting of star connected capacitors, Darlington pair of transistors, a four winding transformer and an additional DC power supply. This active circuit concentrates on the common mode voltage detection at the inverter output, and transfers to the voltage follower amplifier and re-injected in to line through the common mode transformer CMT [9].

In this paper, a DC power supply of 575 V is derived from an AC power supply for suppression of the common mode voltage and thereby shaft voltage and bearing currents. The proposed methodology is simulated using MATLAB initially and will executed experimentally in further. But, so far this paper proposed the simulation analysis only. In the previous work of execution, the various authors have implemented active canceller circuits, determined by a suitable modification of the active circuit with a separate DC power supply. Especially, the advantages of a separate DC power supply of the active device and a simulation analysis have been carried. The execution has been evaluated through a high frequency model of a three phase Pulse width Modulation induction motor drive system. And also various results are compared with and without common mode active canceller circuitry.