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BLDC DRIVES USING WITH HIGH-SPEED AND LOW-INDUCTANCE

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ABSTRACT: Due to the simplicity and high reliability, brushless dc (BLDC)motors are widely used in space application. High reliability levels are the vital aspect for ensuring the long-term stable operation of the BLDC motor system which is used in aerospace applications. The fault tolerant control of BLDC motor is of great importance for its continuous operating capacity even under the faulty situation. This paper proposes fault tolerant topology composed of an additional phase Luganda fault protective circuit for the high-speed low inductance BLDC motor. Based on the analysis of the over current and overvoltage phenomenon after the switch faults, an ovel fault isolation and system reconfiguration method is presented. The method can achieve safe isolation and reconfiguration to avoid the secondary fault caused by direct switch of the redundant switch and the faulty switch after the fault diagnosis process. Both simulation and experimental results confirm the feasibility and effectiveness of the proposed method.

Keywords—Brushless dc (BLDC) motors, buck converter, fault tolerant topology, system reconfiguration.

INTRODUCTION

A genetically suspended control moment gyroscope (MSCMG) has attracted a great deal of attention for its significant application in attitude control of spacecraft. It has the encouraging advantages of high-precision, large-moment and long-life owing to the zero friction and enhanced damping of a high-speed rotor. Their liability of the machine drives is one of the most important factors to guarantee the safe, continuous and high performance operation even under some accidents or faults. The work in mentioned that power semiconductor device faults account for about 35% of all motor systems faults, and up to 40% of the three-phase inverter failures occurring due to the power switches. Since the capability of human intervention is limited in space application, the fault isolation and system reconfiguration measure based on reliable fault diagnosis methods is an effective means to ensure the continuous operating capacity after the inverter faults. As an important part of MSCMG for space application in vacuum, the high-speed rotor drive system demands high operating speed and low power loss. Thus, the brushless dc (BLDC) motors with an ironless and slot less stator are always used. Generally, phase pulse width modulation (PWM) control method is extensively applied high-power/low-power BLDC motor drives with a three-phase full bridge inverting circuit. Unfortunately, it would induce serious current and torque ripples for the ironless stator motor which tends to have very low inductance. Moreover, the high-frequency and large-range current ripple will inevitably increase the copper and rotor iron losses. In order to achieve low power consumption, a PWM controlled buck type DC-DC power converter in front of the three-phase bridge inverter is employed for the low inductance BLDC motor drive of MSCMG. However, the introduction of the buck type DC-DC power converter changes the characteristics of three full bridge inverting circuit, and increases the difficulty of its fault-tolerant control. For the fault-tolerant control strategy of the BLDC motor drive system, there are two main tasks: 1) fault diagnosis and 2) remedial strategies to recover from the fault. There has been a lot of research done in the field of fault diagnosis of inverters in three phase BLDC motor drive systems . Especially in, an online mode-based inverter fault diagnosis method for three-phase full bridge inverter with buck DC-DC converter is proposed. Thus, the focus of this paper is the remedial technique which includes the design of hardware topology and software reconfiguration. A necessary condition of the fault-tolerant control of inverter is the inverter topology which has fault-tolerant abilities. Therefore, the system reconfiguration method switch the redundant hardware topology design which have the advantages of high reliability have attracted many researchers in the recent decades. The research in proposes an improved induction motor drive topology with redundant triacs and fuses. The control strategy introduced in this paper allows continuous, disturbance free operation of the drive after inverter or motor phase faults. Correaetal. present a fault tolerant topology with a redundant phase leg connected to the neutral point permitting the fault-tolerant operation of a three-phase induction motor drive system. The research in proposes a remedial strategy against inverter failures based on the same topology in[5]and[7]to achieve smooth torque for PMSM drives. It should be noted that the proposed fault tolerant topologies in may unavoidably increase the system currents and power loss and decrease the maximum motor torque in their post fault operations.

SYSTEM DESCRIPTION OF THE FAULT TOLERANT INVERTER TOPOLOGY

The overall fault-tolerant BLDC motor driver configuration is shown in Fig. 1, which includes a redundant three-phase full bridge, a redundant buck converter and a fault protective circuit. Similar to , the buck converter is used to adjust the current of the windings, and the current control type is applied to the buck converter. The redundant switch T10 is the hardware backup of the buck converter switch T7. The switches Q1 and Q2 are used to isolate the faulty switch and connect the redundant switch after the switch fault in the buck converter. The fourth leg composed of switches T8 and T9 is used as a hardware backup of the three phase full bridge. Six triacs Sa, Sb, Sc, Sra, Srb, Src are used to compose the fault switching circuit of three-phase full bridge. The fault protective circuit composed of a power resistance R1 and a MOSFET T11 is used to isolate the overvoltage phenomenon caused by the switch open-circuit or short-circuit faults in the three-phase full bridge or the buck converter. The initial inverter topology and post fault inverter topologies after switch fault in buck converter or three-phase full bridge are shows the post fault inverter topology after success switch faults in both buck converter and three-phase full bridge. Depending on the fault-tolerant drive system, the first three topologies all have certain fault-tolerant capacity. The faults should be detected and identified in order to realize the post-fault strategies are classified as

1) Open-circuit damage of switch in redundant buck converter (F1);

2) Short-circuit damage of switch in redundant buck converter (F2);

3) Open-circuit damage of single switch in redundant three phase bridge (F3);

4) Short-circuit damage of single switch in redundant three phase bridge (F4).

Taking the switch fault of T1 in the three-phase full bridge or switch T7 fault for example, the topology modes of the proposed fault-tolerant inverter.

CIRCUIT DIAGRAM

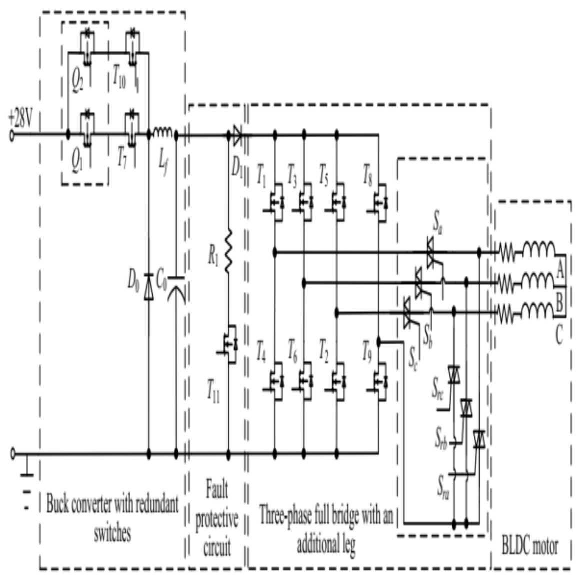

Fig1: Proposed fault-tolerant topology for inverter of high-speed BLDC motors.

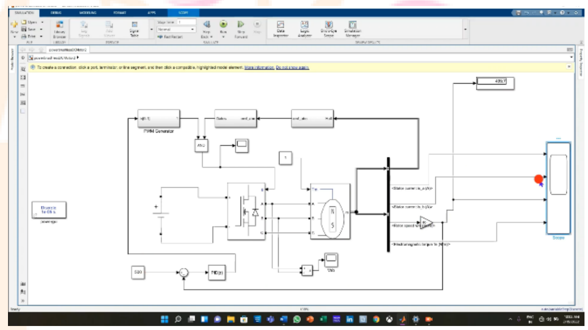

Fig2: Circuit designed in MATLAB Simulink

There is speed and power dissipation tradeoff in the comparator design. With limited speed of the comparators, both rising- and falling-edge propagation delays of the ZVD are limited to tens of nanoseconds. It should be noted that the capability of minimizing the value of the power inductor in the power stage is crucial for lowering the bill-of-material cost and the board area, and the required inductance value is inversely proportional to the switching frequency of the LED driver. The long propagation delays of the ZVD would increase the system delay of the controller, thereby limiting the maximum operation frequency and the minimum inductance value of the LED driver.

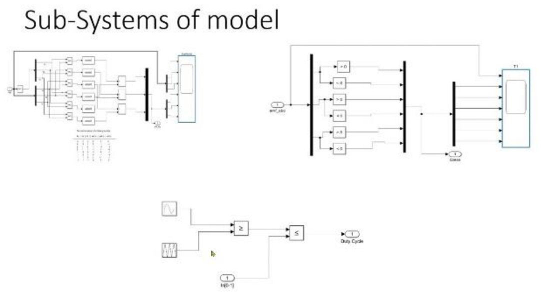

Fig3: Sub system designed in Simulink

PROJECT KIT

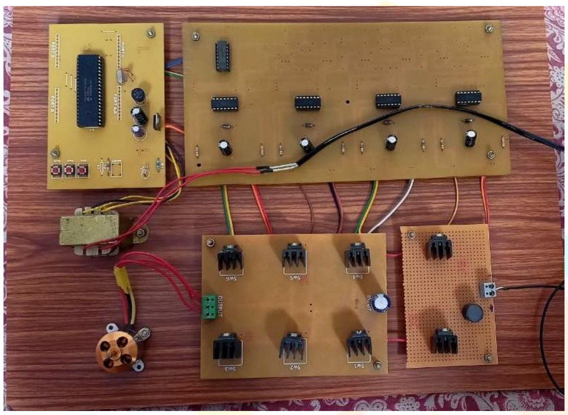

Fig4: Assembled project hardware of BLDC motor for high speed-low inductance

SIMULATION OUTPUT

After completing the circuit design of all the sub system model have to add in main BLDC Circuit and allign them with PWM and Mosfet with Scope then checked every scope we used and for main PWM Scope we used to take for our simulation result of this whole system to obtained the high speed low inductance PWM for BLDC drives.

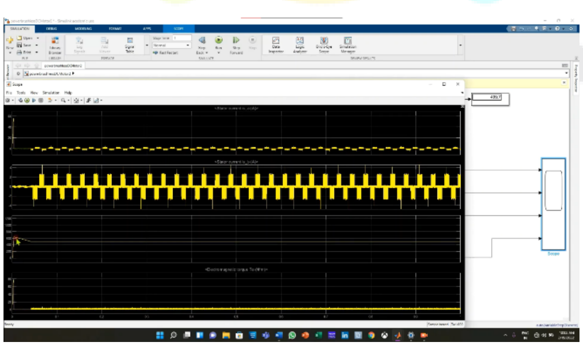

Fig5: simulation result using MATLAB Simulink.

CONCLUSION

In this paper, a fault tolerant topology and a system reconfiguration scheme for the high-speed low-inductance BLDC motor used in space application is proposed. The method can achieve safe post fault isolation and reconfiguration to avoid the secondary fault caused by direct switch of the redundant switch and the faulty switch after the fault diagnosis process. The system reconfiguration can be implemented rapidly and effectively after the open-circuit or short-circuit switch fault by the proposed method. Simulated and experimental results verify the validity of the proposed fault diagnosis method.

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