Fault Diagnosing Technique For Replacing Damaged Igbt Device In Induction Motor Drive

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Abstract

This paper presents a substitution of the damaged power device in open and closed loop control for for fault tolerant towards an Induction Motor Drive (IMD). It depends on fuse blown strategy and early recognition of failure of the power device. The auxillary (Insulated Gate Bipolar Transistor (IGBT) is subbed in each stage and the method actualized is classified "Single Phasing Technique" (SPT). In an Induction motor, the strategy previously utilized was to distinguish short circuits (or) open circuits disappointment in power drives. Be that as it may, there was no substitution had made for damaged component. Fault location must be observed so as to avoid extremely high current during issue time by short circuit of power device. Presently in this paper the damaged power component is substituted in suitable time with appropriate spread time delay and along these lines the drive will run with no interferences and henceforth the following interventions are checked or recognized during transient condition. By taking care of this kind of method, the solid activity can be accomplished for an acceptance engine drive utilizing IGBT. The simulation and exploratory outcomes are acquired so as to approve the procedure proposed.

Key words: *Induction Motor Drive (IMD), Insulated Gate Bipolar Transistor (IGBT), Single Phasing Technique (SPT).*

1. Introduction

This paper discusses a rapid growth in developing a system without fault which makes the equipment more reliable in active and passive fault control. The active way deals in determining the size and location of fault and its diagnosis of fault tolerant mechanism. The passive way deals the sensible for finding certain failure in a closed loop system. For reducing the corresponding problem, there is in need to undergo the solution known as fault tolerant mechanism. The fault tolerant mechanism enrolls certain mechanism like replacement of damaged element. Under such case we an active IGBT by means of bidirectional switches consists of poles are provided. Consider a three phase induction motor, there are three pairs of IGBT connected across its frame work. In case any one pair of IGBT undergoes fault at any phase, a pair of another IGBT known as “auxiliary IGBT” is provided and the drive can run without any interruption.

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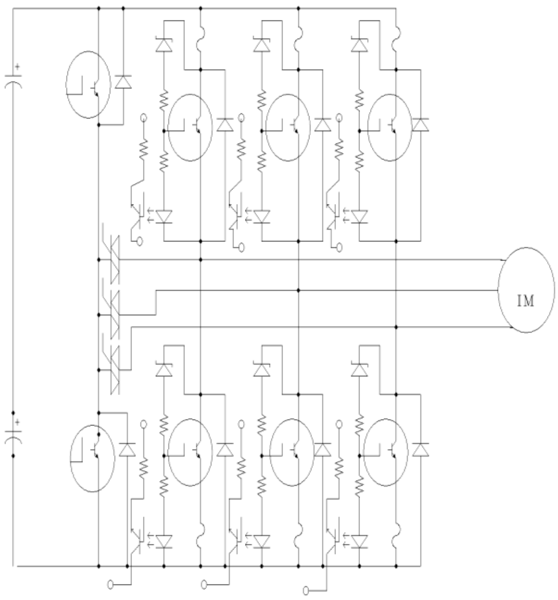

Fig.1: Proposed Fault tolerant scheme for Induction motor drive.

2. Detection and identification of the fault

The detection and identification of the fault, or diagnosis, permits us to determine the post-fault action. The effect of a short-circuit or an open-circuit fault verified in one or two power switches of the same inverter leg can be represented by an error in the inverter pole voltages with respect to the reference voltages used to generate the command signals.

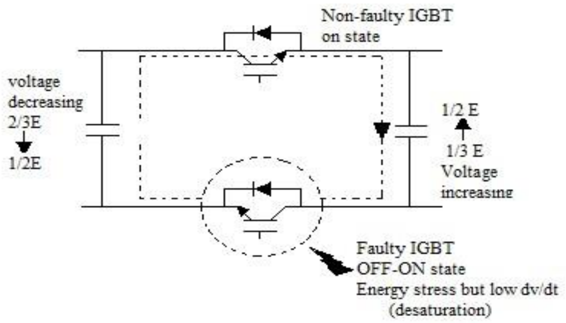

Fig.2: Short circuit detection

Consider as representing the deviation in the pole voltage due to a fault in switch. The detection of the fault occurrence can be determined by detecting the voltage error obtained from the comparison between the measurement of the pole voltage and its respective reference voltage. The discretization error, introduced by the measurement procedure and the modulation technique employed. That can be minimized by using a calibration procedure on the acquisition module of the motor drive. After calibrating, the voltage error can be approximated.

3. **Fault tolerant stratagies**

The main ways to find the fault tolerant in the induction motor drive are

(i) Gate voltage monitoring. (ii) V_{ce} monitoring.

(iii) GATE VOLTAGE MONITORING

Failure detection of IGBT is carried out by means of the measurement of IGBT gate voltage signal. It is well known that the destruction of an IGBT is caused by phenomena that are outside the safe operational area (SOA). IGBTs internal structure has the depletion region can be noted clearly which is more vulnerable to fault.

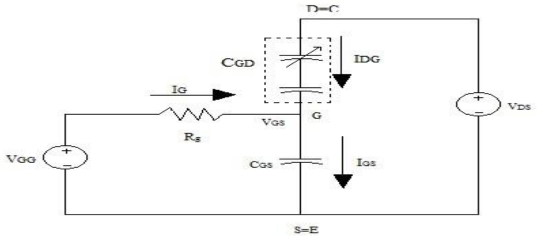

Fig.3: Monetization of Gate voltage

This region has great mobility during turn-on transient and is represented by several variables capacitances but only CGDJ is part of equivalent circuit of IGBT gate voltage signal because CGD = COXD + CGDJ. The capacitances involved in the IGBT gate charge signal are shown in the Fig.3. Where COXD and CGS are constant capacitances formed by oxide of IGBT design and CGDJ.

V_{CE} MONITORING

IGBT failure is also detected by the help of collector emitter voltage monitoring. Gate voltage and current signature analysis are complicated compared with Vce monitoring. Whenever the safe operating area excess it cause damages to the IGBT. The safe operating is noted by Vce monitoring method.

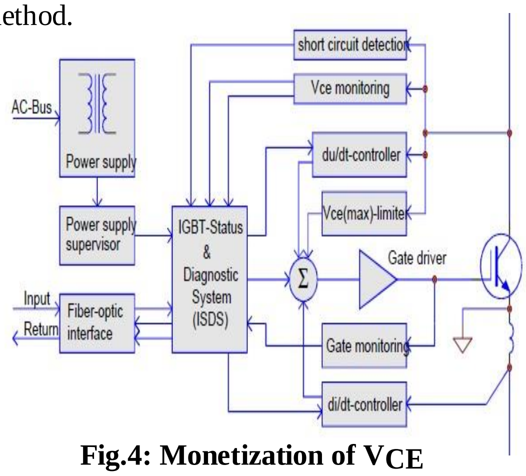

Fig.4: Monetization of V_{CE}

Whenever the faults occur in the IGBT the drive operation has to be stopped for a non programmed maintenance schedule. The cost of this schedule can be high and this justifies the development of fault- tolerant motor drive systems. The effect of the power inverter faults on the operation of the electrical machine, faulty diagnosis methods and reconfiguration schemes for isolating the faulty power devices and fault compensation techniques for improving reliability on the motor drive systems.

4. Replacement of damaged element

The most common faults in the induction motor drive are the failure in the power devices of inverter. These faults can happen by short-circuit or open circuit in the device. In a fault-tolerant induction motor drive is very important that the diagnostic and electrical isolation must be executed as soon as possible. In this way, it is necessary to use techniques of very fast detection in order to avoid a very dangerous currents during the fault time by short- circuit of the power device. On the other hand, the delay time of the electrical isolation stage is limited by the energy i^2t of fuse and although the manufacture technology has improved, still the blown time is of the order of milliseconds. Therefore, it is impossible to make the quickly replacement of damaged element because this one is limited by the time of electrical isolation. This is the reason why the replacement time must be done in the suitable time.

In an induction motor drive the fault occurs due to very high current in the power device (IGBT) Whenever anyone of the main IGBT is failed in any phase at the time failure IGBT phase is cut the power supply in that particular phase. So in that three phase supply, one supply is out of the connection and the other two phases shares the equal amount of the supply current due to the absence of the third phase. So in this case the high current flows through the other two phases. This high currents cause damaged to the windings of rotors in the three phase induction motor. So we want to prevent the damage in the induction motor drive. So in this case we provide an auxiliary IGBT's to prevent this damage and run the plant without any interruptions and losses.

When a failure occurs in the power device the phase current tends to zero. Therefore the input stator voltage of the induction motor is equal to zero (V (abc) s = 0) where (a, b, c) represent the damaged phase. So this has to be first step-down to a suitable level. Hence a step-down transformer of rating 230/18, 0, -18V is employed to reduce the voltage level to 18V AC. This is then passed to bridge rectifier which converts the AC output of the transformer to DC. But the rectifiers DC output has some ripple or pulsation, so to reduce the ripples a filter part is employed which is nothing but a set of capacitor.

The rectified output is given to the IGBTs. Whenever anyone of the IGBT is fault during the running of the induction motor drive, the auxiliary IGBT substitutes for the faulty one. For the six main IGBTs, two auxiliary IGBTs act as the substitute. The auxiliary IGBT's are turned ON by a triac switch. There are three TRIAC for turning ON the auxiliary IGBT's**.** Whenever any IGBT is damaged the auxiliary IGBT is replaced. In that time circuit is opened to substitute another auxiliary active IGBT to the suitable place. The auxiliary IGBT is substituted by perfect operating of the suitable TRIAC switch to close the circuit for the reliable operation. Whenever the IGBT is damaged the optocoupler senses the signal and send this signal to the microcontroller. The microcontroller senses the optocoupler signal and substitutes the IGBT in the faulty part via suitable switching of the TRIAC in few milliseconds by the timer operation.

5. Reconfiguration of the inverter topology

Fig.5 shows two "healthy" three-phase machine drive configurations. The first inverter topology has four legs, composed of switches. The fourth leg composed of switches is used as a hardware backup.

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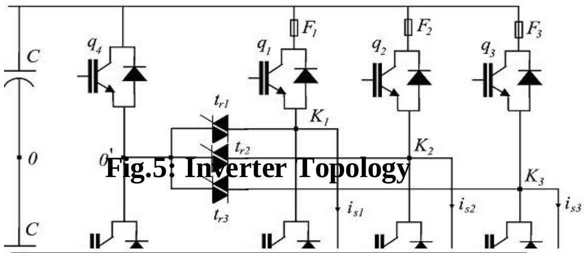

Fig.5: Inverter Topology

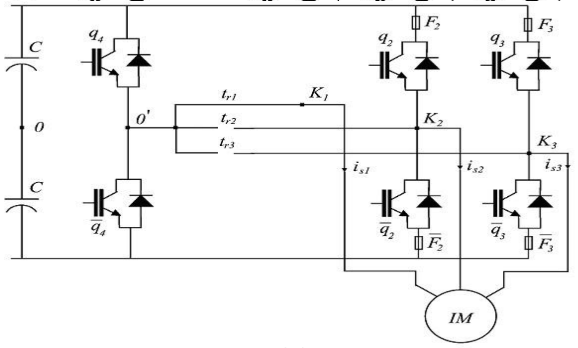

Fig.6: Isolation of faulty IGBT

After the diagnosis and isolation of the faulty leg, the reconfiguration is obtained by using the triac that is triggered on to interconnect the point to point 0' shows the inverter topologies obtained after the execution of that procedure for compensating the fault occurrence in the switch.

6. Sub system components during normal mode of operation

Fig. 7 consists of a three phase rectifier, Main IGBT's I 1, I 2, I 3, I 4, I 5, & I 6, Auxiliary IGBT's AI 1&AI 2, Filters F1&F2, TRIAC T1, T2, T3, UFC-UJT firing circuit

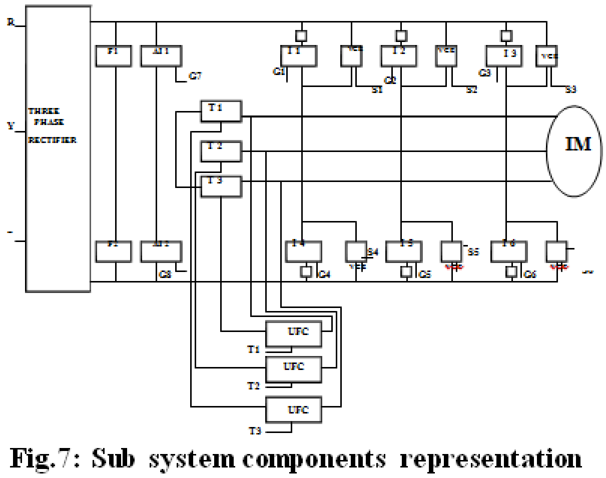

Fig.7: Sub system components representation

VCE M - Collector Emitter Voltage Monitoring S1, S2, S3, S4, S5 & S6 - Sensing of Main IGBT signals, G1, G2, G3, G4, G5, G6, G7 & G8 - Gating Signals of IGBT's

7. Modelling & Simulation result

Fig.7 shows the open loop circuit for three phase induction motor. It consist of three phase voltage source of 440V and is fed to the one end of abc subsystem. The subsystem consist of nine IGBTs connected in antiparallel connection. In each phase each IGBT is substitute with auxiliary IGBT. If the main IGBT fails the auxiliary IGBT is substituted. The each IGBT in this phase is calibrated with ratings internal resistance 1e-3 and snubber capacitance 1e5. The another end of subsystem ABC is connected to the three phase induction motor. From the three phase induction motor the rotor speed, stator current are simulated.

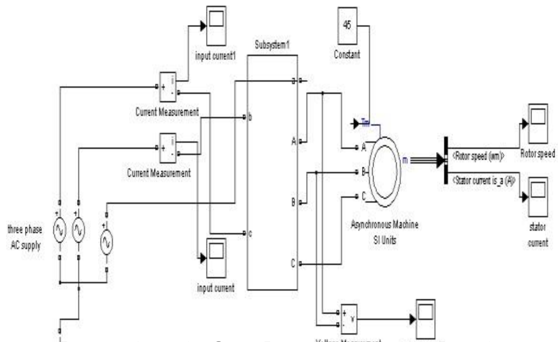

Fig.8: Open loop circuit for three phase induction motor

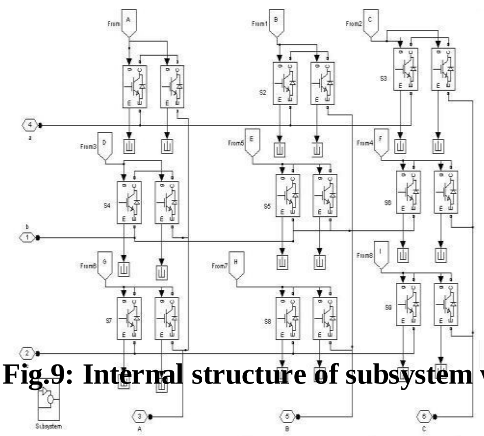

Fig.9: Internal structure of subsystem with IGBT

The speed of the motor at starting is high then it reaches the constant speed. The motor speed is directly proportional to toque characteristics. When the torque is high, speed is reduced. When the toque is low, the speed increases. The value speed in this waveform is 148 rpm. From the above waveform torque is 45 N/m the corresponding rotor speed is 148 rpm measured from the simulation waveform.

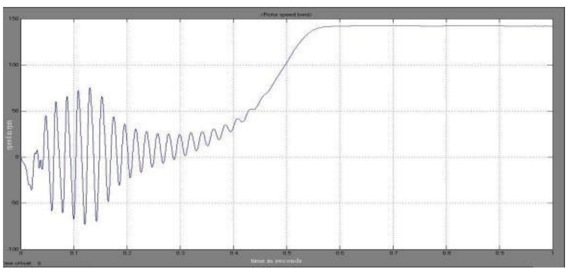

Fig.10: Rotor speed

The stator current is high at starting of the motor. Then it attains the normal state. The value of the stator current is 0-164 amps and in normal state 0-25 amps.

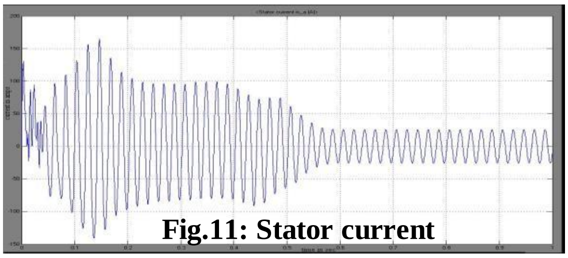

Fig.11: Stator current

The value input current and stator voltage is 25amps and 390V.

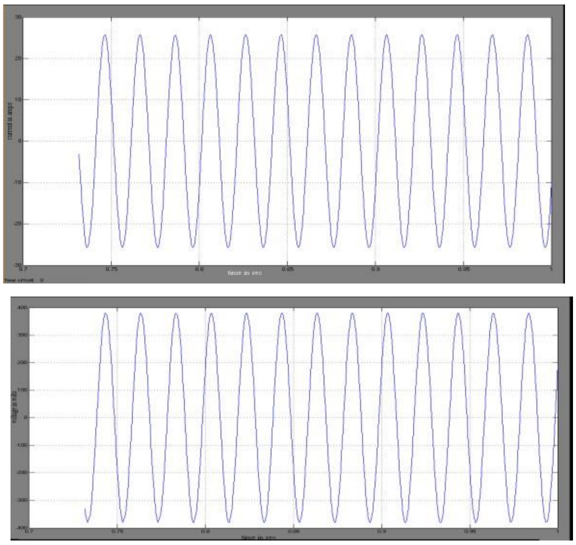

Fig. 12: Input current & Input voltage

8. Conclusion

The stages for fault diagnostic and electrical isolation in fault-tolerant sequence for induction motor drive must be executed as soon as possible. It is because during this period a dangerous current appears inside the drive. In addition, the replacement of damaged element must be activated in the most suitable time in order to decrease the tracking error of motor current at the instant that the power semiconductor is replaced.

In this way, for an open-loop control with low dynamic response as Volts/Hertz strategy the most suitable time to replace the power device is at zero crossing of the motor current.

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