Novel Model Predictive Control for Fault Analysis of Electrical Machine Drives

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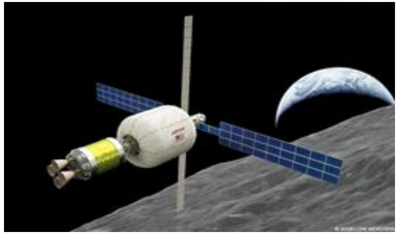
Introduction

- ❖ Electrical machine drives play a vital role in various applications and hence it's control system design became more significant since last decade for the developing world[1].
- ❖ In various high power and high-efficiency machine drives, continuous operation necessitates despite the fault[2].
- ❖ Fault tolerant control is an effectual solution for the reliability of drive[3].
- ❖ Model Predictive Control (MPC) is an optimal control algorithm developed for constrained control of Multi-Input-Multi-Output (MIMO) systems[4].
- ❖ To a certain extent, MPC faces a problem in achieving the robustness against the model mismatches and noises[5].
- ❖ In this research, the proposed solution is to develop a Novel Model Predictive Control (NMPC) method which assures better performance of the drive and minimizes fault clearance time.

HIGH SPEED TRAIN



SATELLITE

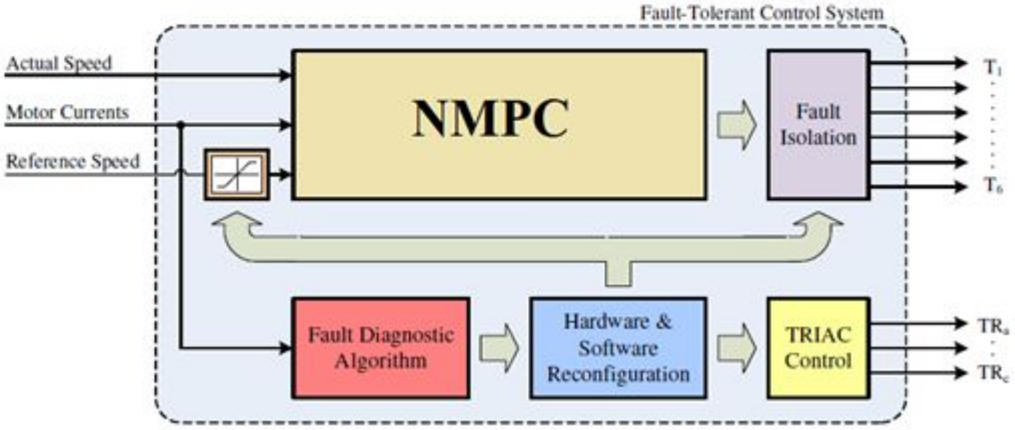
ELECTRIC VEHICLE

Objective

- ❖ To get fast speed tracking and reduce the rise time.
- ❖ To reduce the overshoots during the transients.
- ❖ To reduce fault clearance time of inverter single phase open circuit fault (SOCF).
- ❖ Maximize a profit function, minimize a cost function, or maximize a production rate.

The control system must be able to achieve the following four steps:

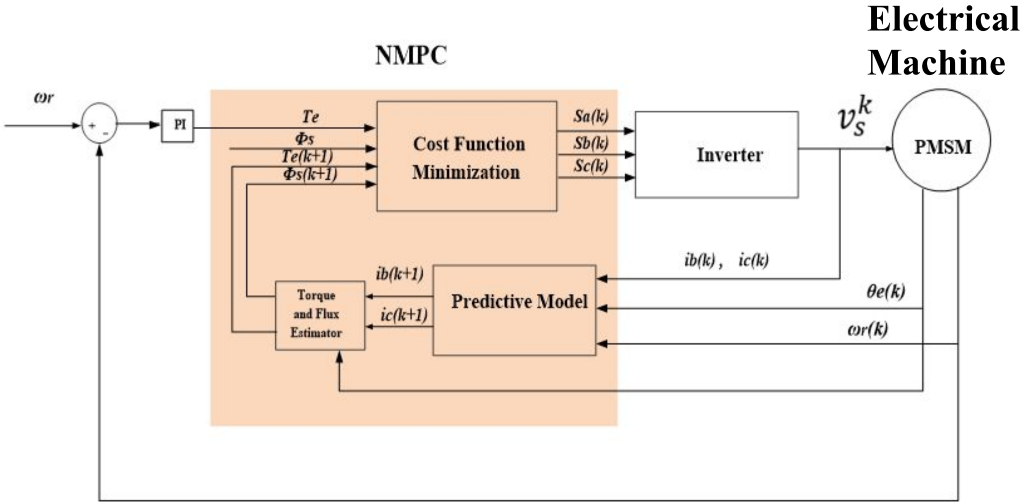
- ➢ Fault diagnosis
- ➢ Faulty leg isolation
- ➢ Hardware reconfiguration
- ➢ Post-fault software control

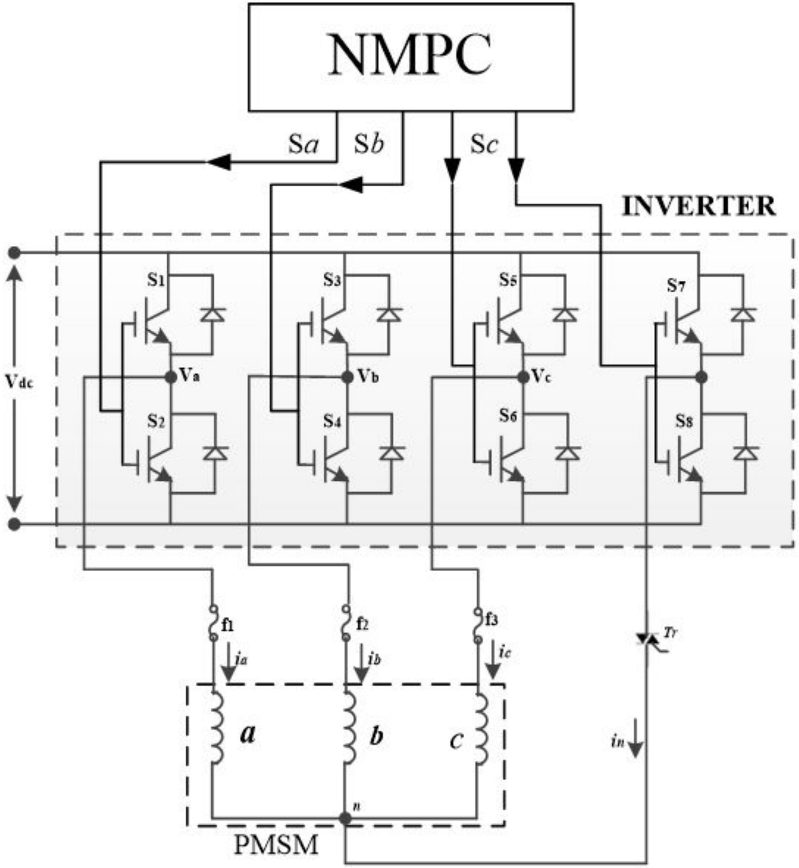


Block Diagram of a Fault-Tolerant Control Drive

Methods

Proposed Fault Tolerant Machine drive





PMSM---Permanent Magnet Synchronous Motor

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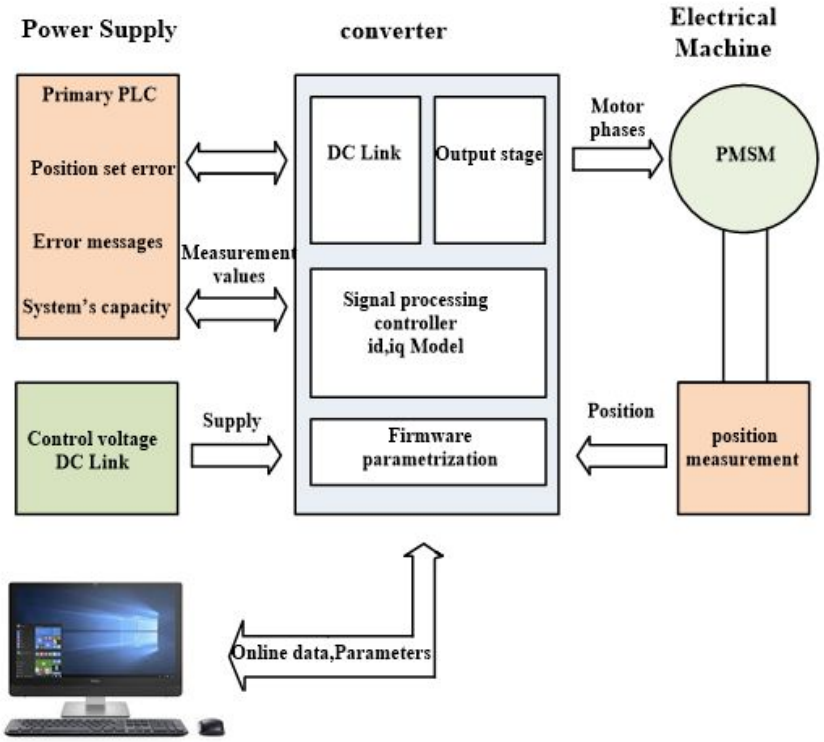
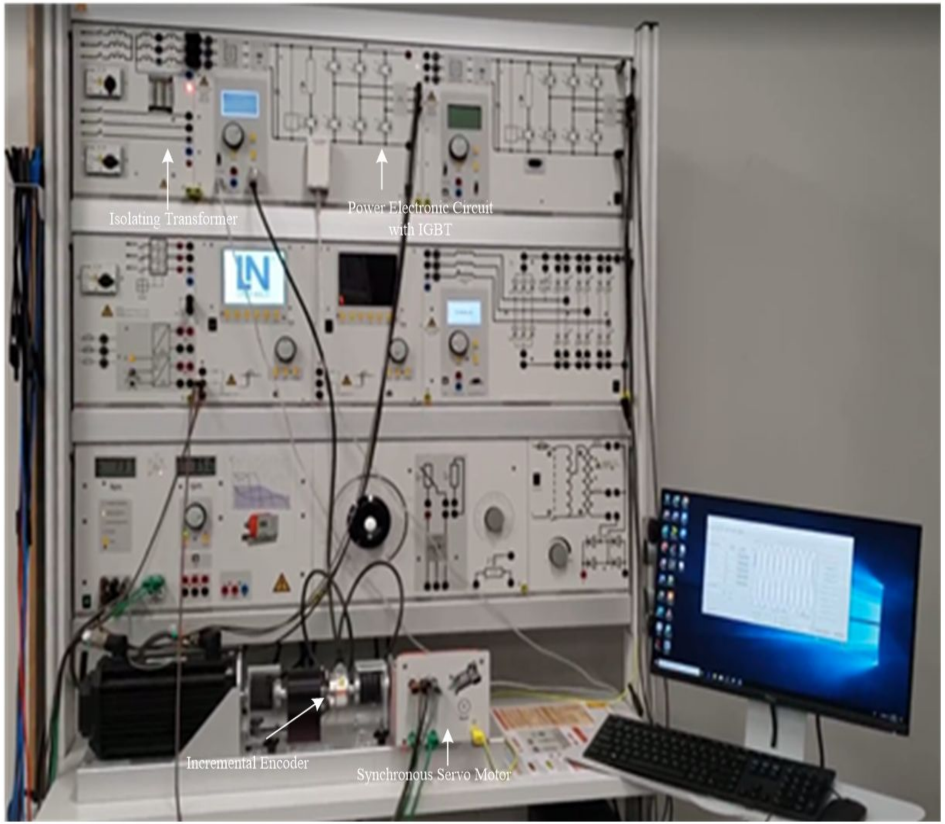
Methods



Experimental Set-Up
(Lucas Nulle Servo Drive system)



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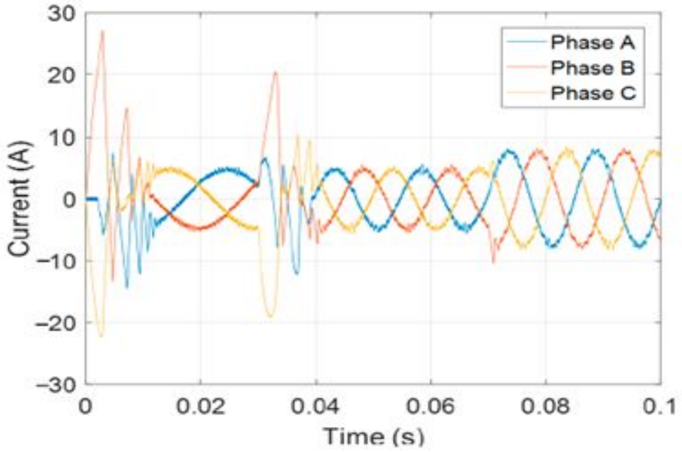
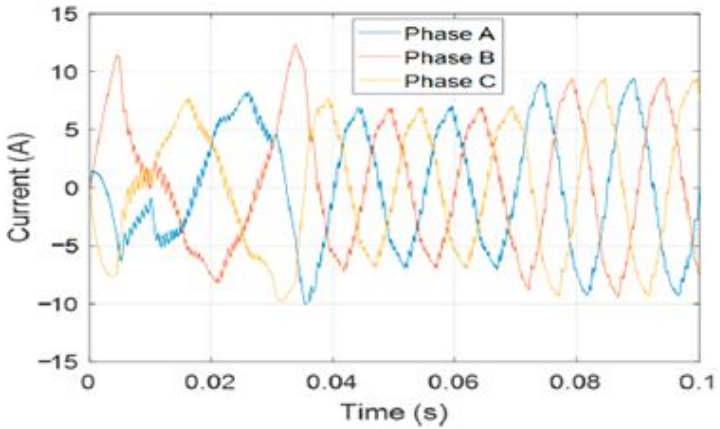
Results(Simulation)

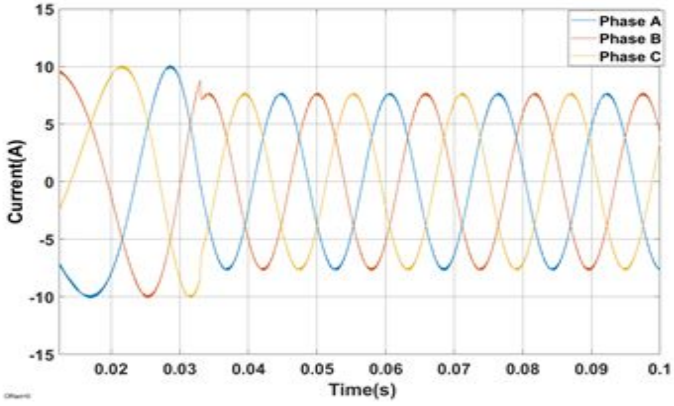
Space Vector Pulse Width Modulation (SVPWM)



Model Predictive Control (MPC)



Proposed NMPC



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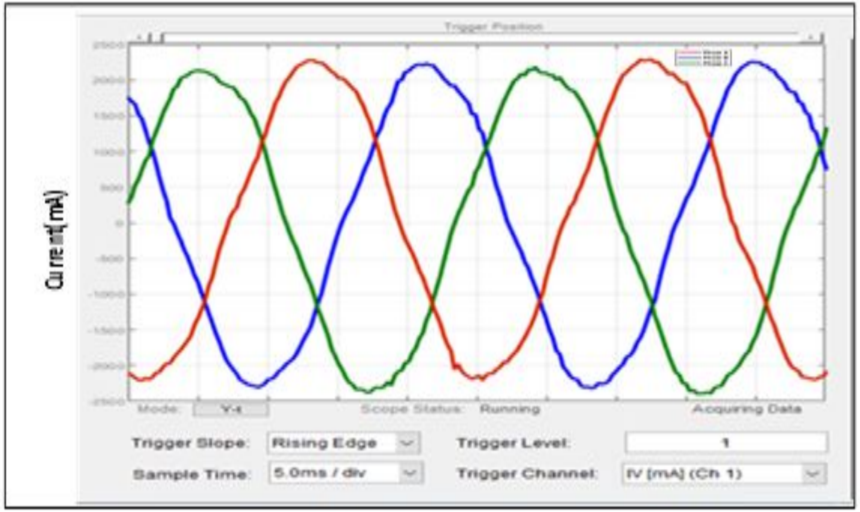
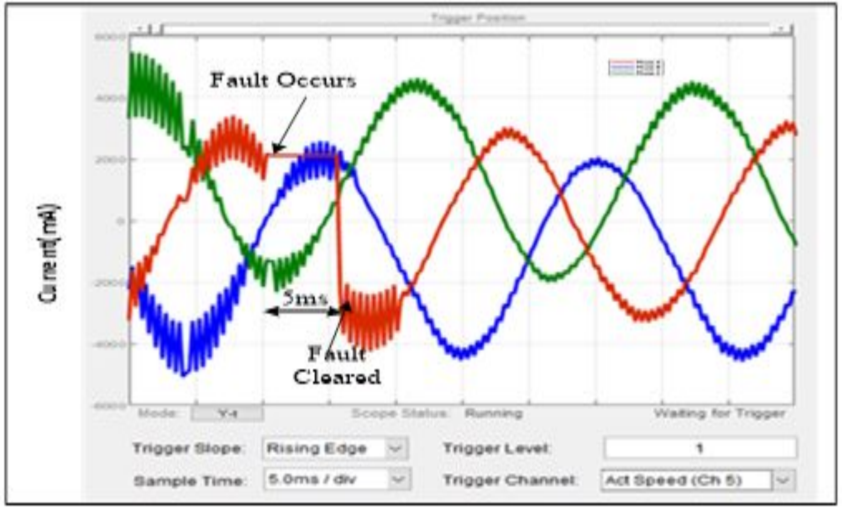
Results(Experimental)



Three-Phase Currents before the fault



Three-Phase Currents after SOCF

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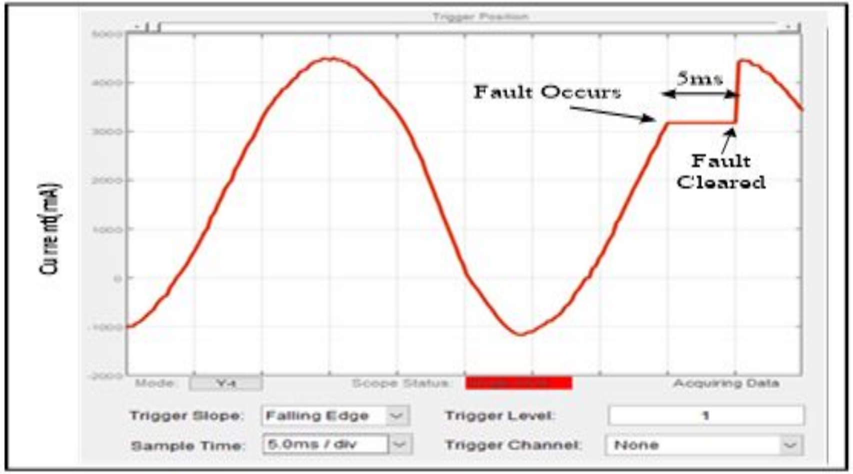
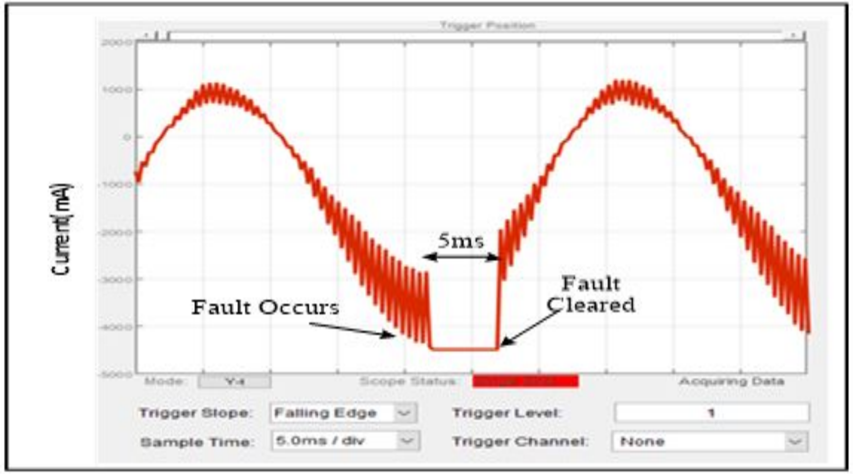
Results(Experimental)



Phase A current under the occurrence of SOCF at Speed=1000 rpm



Phase A current under the occurrence of SOCF at Speed=500 rpm

Results

Comparison of Fault Clearance Time

Existing Control Methods	**Fault Clearance Time**
Current Residual Vector method	<1/4 Tc
Allelic point function method	About 1/4 Tc
Non-Linear P-I Observer	<1.5 Tc
Normalized Line-to-Line Current	<Tc
Proposed NMPC	**1/6 Tc**

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Tc----fundamental period of the phase current

Conclusions

- A fault-tolerant Electrical Machine (PMSM) drive integrating a real-time fault diagnostic method for single-phase open-circuit fault, has been presented in this proposal.
- The proposed drive system's key component is the developed fault-tolerant control that incorporates the main control routines regarding the PMSM vector control and the diagnosis and reconfiguration process algorithm.
- Implementation of the proposed algorithm for PMSM drive, employing novel model predictive control considering circuit faults, has been carried out using Lucas Nulle Servo Drive system with MATLAB Simulink.
- The experimental results show the effectiveness of the proposed algorithm.

Future work

- ❖ Future work is to analyze proposed NMPC for other different faults such as short circuit fault and permanent magnet demagnetization fault.
- ❖ Implement the proposed NMPC considering various machine drives with different types of motors.

References

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